HOPPECKE

POWER FROM INNOVATION


# Installation, commissioning and operating instructions

for vented stationary lead-acid batteries

www.hoppecke.com

## Table of contents

# 1 Preface

Dear customer,

Thank you very much for choosing a product from our company.

Before carrying out any activities related to lead-acid batteries, we ask you to read this documentation carefully and calmly. It contains important information on the safe and professional unpacking, storage, installation, commissioning, operation and maintenance of lead-acid batteries. Failure to follow the safety instructions can lead to serious personal injury and property damage. We assume no liability for direct and indirect damage resulting from improper handling and any warranty claim expires.

We reserve the right to make changes to the content of this documentation. HOPPECKE Batterien GmbH & Co. KG is not liable for any errors in this documentation. Liability for indirect damages arising in connection with the use of this documentation is also excluded. Our products are constantly evolving. Therefore, there may be discrepancies between the representations in this documentation and the product you purchased.

Please keep this documentation in such a way that it is immediately available to all persons who need to carry out activities related to the batteries.

If you have any questions, we will be happy to help you. You can reach us at the following e-mail address:
info@hoppecke.com
or by telephone on working days between 8.00 a.m. and 4.00 p.m. (CET) at
Phone +49(0)2963 61-0
Fax +49(0)2963 61-481.

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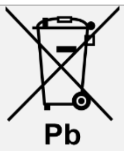
# 2 Safety notices

When handling the batteries and their components, observe the following safety instructions. Please also note the information in the ZVEI leaflet "Information on the safe handling of lead-acid batteries (lead-acid batteries)".

## 2.1 Explanation of the symbols used in the manual

| | | | |
|---|---|---|---|
|  Danger! | There is a risk to the health of persons, to the battery(s) or to the environment. Failure to comply with these hazard warnings can result in serious injury or even death. |  | Danger from explosion, pressure waves, hot or molten substances flying around. Explosion and fire hazard, avoid short circuits. Failure to comply with these hazard warnings can result in serious injury or even death. |
|  Attention! | There is a risk to the battery(s), to objects or to the environment. Dangers to people are not to be expected. Failure to do so may result in malfunctions and damage to the battery(s). Furthermore, property damage and environmental damage can occur. |  | Risk of chemical burns due to leaking electrolyte. Electrolyte is highly corrosive. |
|  | Danger to life and health due to electrical voltages. Failure to comply with these hazard warnings can result in serious injury or even death. |  | Warning of battery hazards. |
|  | Recycling/Reuse |  | No smoking. No open flame, embers or sparks near the battery, as there is a risk of explosion and fire. |
|  | Use protective clothing |  | Wear conductive footwear. |
|  | Use eye protection |  | Use face shields |
|  | Use handguards |  | Hint |
|   | Lead-acid batteries that are not used in the recycling process must be disposed of as hazardous waste in compliance with all regulations. |  | Take first aid measures |

## 2.2 Explanation of the symbols used on the battery

| | | | |
|---|---|---|---|
|  | Warning of a danger spot. |  | Danger of explosion. Avoid short circuits |
|  | Danger from electrical voltage. |  | Risk of chemical burns due to leaking electrolyte. |
|  | Wear safety goggles when handling battery cells/blocks. |  | Avoid open flames and sparks. |
|  | Observe the operating instructions for assembly, commissioning and operation. |   | Battery with low antimony content. |
|  Pb | Used batteries that cannot be recycled must be disposed of as hazardous waste in compliance with all regulations. |  | Recycling/Reuse |

## 2.3 General information

As a result of damage to the battery housing of filled lead-acid batteries, electrolyte, acid vapors or even hydrogen gas can escape. Therefore, always follow the safety precautions for handling lead-acid batteries.


Attention!

Lead-acid batteries contain lead metal (CAS No. 7439-92-1), a substance on the REACH Candidate List.


Danger!

Improper use of the products described here may result in personal injury and property damage.
In the event of improper use, HOPPECKE assumes neither responsibility nor liability for direct or indirect personal injury or property damage resulting from the handling of the products described here.


Attention!

Without proper and regular maintenance of the batteries by HOPPECKE specialists (or personnel trained by HOPPECKE), the safety and reliability of the power supply in an emergency may not be guaranteed.


Danger!

Work on batteries, in particular their installation and maintenance, may only be carried out by trained HOPPECKE specialist personnel (or personnel trained by HOPPECKE) who are familiar with the handling of batteries and know the necessary precautions.

**Method for absorbing spilled acid:**

Electrolyte is highly corrosive! In normal operation, contact with the electrolyte is excluded. When the housing is destroyed, the bound electrolyte released is just as corrosive as it is more liquid.

Set spilled acid with binder, e.g. sand, and neutralize with lime, soda or caustic soda. Then dispose of in accordance with the official, local regulations. Do not allow to get into the sewer system, soil or water. To neutralize electrolytes, the chemicals suggested in the table below are used.

When neutralizing small amounts of electrolyte, all protective measures must be observed.

Danger!

The required quantities of chemicals (see Table 2.5.1-1) are to be stirred into the electrolyte in small portions.

Particular care must be taken when adding soda (strong foaming).

Danger!

The endpoint of neutralization is reached at a pH value of 6 to 8. If a corresponding measuring device is not available, the degree of neutralization can be checked using a commercially available indication paper. Neutralization is complete when the discoloration of the indication paper appears olive green to yellow. A blue coloration indicates that the neutralization point has already been exceeded. Back neutralization must then be carried out by adding acid. Gel electrolyte from damaged batteries or from used batteries can be disposed of accordingly.

To neutralize 1 liter of electrolyte of the listed nominal densities, the following amounts of lime, soda ash or caustic soda are needed:

*Table 2.5.1-1 - Chemicals used to neutralise 1 litre of electrolyte*

| **Nominal density** | **Lime (kg) CaO** | **Soda (kg) $Na_2CO_3$** | **Natronlauge (l)** | |
|---|---|---|---|---|
| | | | **NaOH 20%** | **NaOH 45%** |
| 1.20 kg/l | 0,19 | 0,36 | 1,36 | 0,60 |
| 1.24 kg/l | 0,23 | 0,44 | 1,65 | 0,73 |
| 1.27 kg/l | 0,26 | 0,50 | 1,88 | 0,83 |
| 1.29 kg/l | 0,28 | 0,54 | 2,03 | 0,90 |

Please also observe all regulations, writings and standards, as described in chap. 3.5 .


Danger!

Risk of fire, explosion or burns. Do not disassemble, heat above 45°C or burn.

## 2.4 Personal Protective Equipment, Safety Clothing, Equipment

When working on batteries, wear face protection (impact-resistant visor according to EN 166 Class F or comparable), safety goggles, protective gloves and protective clothing!
Observe the accident prevention regulations as well as DIN EN 50110-1 and IEC 62485-2 (stationary batteries) or IEC 62485-3 (traction batteries).

When handling lead-acid batteries, at least the following equipment must be available:

- Voltage-insulated tool
- Rubber gloves
- Safety shoes
- Fire extinguisher
- Rubber apron
- Goggles
- Acid binder for the rapid neutralization of spilled acid (see chap. 2.3)
- Face protection (impact-resistant visor according to EN 166 class F or comparable)
- Face mask
- Emergency eyewash (recommended)

To avoid electrostatic charging when handling batteries, textiles, safety shoes and gloves must have a surface resistance < $10^8$ ohms and an insulation resistance ≥ $10^5$ ohms (see IEC 62485-2 and DIN EN ISO 20345:2011 Personal protective equipment – safety shoes). If possible, wear so-called ESD shoes.


Danger!

Put down watches, rings, necklaces, jewelry and other metal objects when working with batteries.
Never smoke in the immediate vicinity of batteries, handle open flames or generate sparks.
Never place tools or metal parts on batteries.

The use of proper tools and protective equipment can prevent injuries or mitigate the consequences of injury in the event of an accident.

## 2.5 Safety precautions

### 2.5.1 Sulfuric acid

Batteries are safe when handled properly. However, they contain sulfuric acid ($H_2SO_4$), which can cause severe chemical burns and serious injuries.

Danger!

Always wear protective gloves when handling lead-acid batteries and use proper tools.
Please note the following information and read the ZVEI leaflet "Information on the safe handling of lead-acid batteries".
The battery room should urgently have the following facilities:

- Emergency kit to collect leaked electrolyte
- Substances mentioned below for emergency use

**In case of skin contact with sulfuric acid, immediately:**

- Take off contaminated clothing
- Dab acid with cotton or paper towel, do not rub
- Rinse the skin area generously and carefully with water
- Wash thoroughly with soap after rinsing
- Avoid contact with unaffected parts of the body
- If necessary, consult a doctor

**In case of sulfuric acid in your eyes immediately:**

- Rinse the eye carefully for 15 minutes with large amounts of water (using running water or an eyewash bottle)
- Avoid too much water pressure
- In any case, consult an ophthalmologist immediately

**If electrolytes are swallowed:**

- Drink plenty of water immediately
- Consult a doctor or hospital immediately
- Until the doctor arrives: If available, swallow activated charcoal

**In case of contact of clothing or other material with sulphuric acid, immediately:**

- Take off contaminated clothing
- Wash clothes in sodium bicarbonate solution (baking soda or baking soda)
- If no more bubbles rise, rinse with clean water

### 2.5.2 Explosive Gase

Danger!

Inside lead-acid batteries is an explosive hydrogen/oxygen-gas mixture that can leak out of the battery. In the event of an explosion of the mixture, serious personal injury can occur due to flying particles.

- Always wear prescribed protective clothing (face protection (impact-resistant visor according to EN 166 Class F or comparable), safety goggles, voltage-insulating gloves and safety shoes, etc.)
- Use only proper tools ("non-sparking", with voltage-insulated handles, etc.)
- Prevent any ignition sources such as sparks, flames, arcs
- Prevent electrostatic discharge. Wear cotton clothing and ground yourself, if necessary, when working directly on the batteries

Danger!

In the event of a fire, extinguish exclusively with water or $CO_2$! Do not point the fire extinguisher directly at the battery(s) to be extinguished. There is a risk that the battery housing will crack as a result of thermal stress. Furthermore, there is a risk of explosion due to possible static charges on the battery surface. Turn off the battery charging voltage.
Use breathing apparatus with a self-sufficient breathing air supply during extinguishing work. When using extinguishing water/foam, there is a risk of reactions with the electrolyte and, as a result, violent splashing. Therefore, wear acid-resistant protective clothing.
When plastic material is burned, toxic fumes can be produced.
In this case, leave the scene of the fire as quickly as possible, unless you are wearing the above-mentioned breathing apparatus.

Danger!

When using $CO_2$ fire extinguishers, there is a risk that the battery will explode as a result of static charge!
Please also note the information in the ZVEI leaflet "Information on the safe handling of lead-acid batteries (lead-acid batteries)".

### 2.5.3 Electrostatic discharges

All lead-acid batteries develop hydrogen and oxygen gas, also known as oxyhydrogen gas, during operation, but especially during charging. These gases escape from the batteries into the environment. In the case of natural or forced ventilation, which must always be provided, it must be assumed that an ignitable hydrogen-oxygen-gas mixture is only present in the vicinity of the battery cell openings. Inside the battery housing itself there is always an ignitable hydrogen-oxygen-gas mixture.

This is true regardless of battery technology, design or manufacturer and is typical of all lead-acid batteries. The energy required to ignite oxyhydrogen is very low and can be released or supplied in the following ways:

Open flames or fire, smoldering sparks or flying sparks during grinding work, electrical sparks from switches or fuses, hot surfaces > 200 °C and – an often-underestimated cause – electrostatic discharges.

**Measures to avoid oxyhydrogen ignition due to electrostatic discharges:**

Please note the following points to avoid electrostatic discharge on the battery, your body or your clothing:

- Do not rub the battery with dry cloth, especially not with a cloth made of synthetic material! Rubbing on plastic surfaces (battery housings are usually made of plastic) generates electrostatic charges.
- Clean battery surfaces only with cotton cloths moistened with water. When wiping with moistened cotton cloths, no charges are built up.
- When working on batteries, avoid letting your clothing (e.g. wool) rub against the battery, as this can build up electrostatic charges on the battery housing or on your body or clothing.
- Wear shoes and clothing with special surface resistance to avoid electrostatic charges on your body or clothing.
- Do not remove labels stuck to the battery without special safety precautions. Removing or peeling plastic labels from plastic surfaces can lead to the accumulation of electrostatic charges, which can ignite oxyhydrogen when discharged. Wipe the battery with a damp cloth before removing the label.

### 2.5.4 Electric shock and burns

Danger!

Before making the connections, check the correct polarity of the batteries!

Batteries can cause severe electric shocks. In the event of a short circuit, very high currents can flow. Do not touch bare battery parts, connectors, terminals and poles. In the case of battery installations with a nominal voltage of more than 1500 V DC, devices for separation into groups of cells of less than 1500 V DC must be available. Be very careful when working on the battery system to prevent serious injury from electric shock and burns.

Always wear prescribed protective clothing (voltage-insulating rubber gloves, rubber shoes, etc.) and only use tools that are made of non-conductive material or are stress-insulated.

Put down watches, rings, necklaces, jewelry and other metal objects when working with batteries.

**Before performing any work on the battery system:**

Check if the battery system is grounded, which we generally do not recommend. If this is the case, disconnect the connection. Unintentional contact with a grounded battery can result in severe electric shock. This risk can be significantly reduced without an earth connection. The racks or cabinets used to hold batteries must be properly grounded or fully insulated in accordance with IEC 62485-2.

**In the case of a grounded battery system** ...

There is tension between the earth and the ungrounded pole. If this pole is touched by a grounded person, there may be a danger to life! There is also a risk of a short circuit if dirt and acid deposits on the ungrounded terminal come into contact with the battery rack.

If there is an (unintentional) additional ground fault via some cells within the (grounded) battery system, there is a risk of short circuits or fire and explosion.

**In the case of an ungrounded battery system** ...

If there is an unintentional ground fault within the battery system, there is an electrical voltage between the earth and the ungrounded pole. The voltage can sometimes be dangerously high – danger to life due to electric shock.

If there is also a second unintentional earth fault, there is a risk of short circuit or fire and explosion.

If you have any questions about the above or any other questions related to safety when working on a battery system, please contact your local HOPPECKE dealer. Alternatively, you can reach us directly at the head office.

# 3 General information

HOPPECKE offers numerous lead-acid batteries as a single cell (nominal voltage 2 V) or block (nominal voltage: 4 V, 6 V or 12 V) for a wide variety of applications.

## 3.1 Specifications

Each cell/battery block has its own nameplate on the top of the cell/block cover. Below is an example.

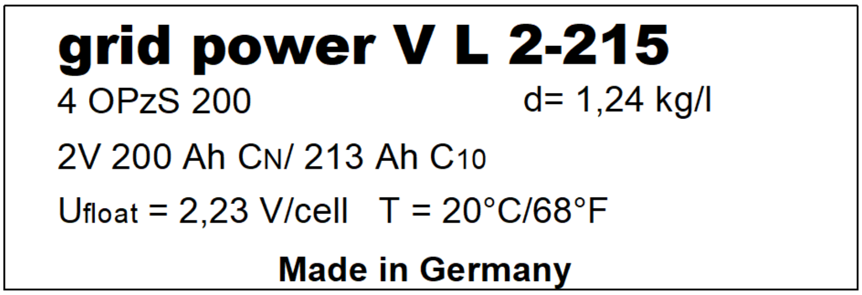


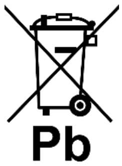

*Figure 3-1 - Nameplate*

The details on the nameplate are: grid power V L 2-215
DIN designation 4 OPzS 200

| | |
|---|---|
| **4** OPzS 200 | = Number of positive plates |
| 4 **OPzS** 200 | = Design |
| 4 OPzS **200** | = Capacity according to DIN $C_{10}$ |
| d | = Electrolyte density |
| $U_{float}$ | = Float charge voltage |
| T | = Reference temperature |
| 213 Ah | = Actual capacity $C_{10}$ (capacity when discharged with ten-hour current ($I_{10}$)) |

## 3.2 Disposal and Recycling

Used batteries with this symbol are recyclable assets and must be fed into the recycling process.




Used batteries that are not used in the recycling process must be disposed of as hazardous waste in compliance with all regulations.

HOPPECKE offers its customers its own battery take-back system. Taking into account:

- Of the Circular Economy and Waste Act
- The Battery Regulation
- The Transport Permit Ordinance
- In accordance with the principles of general environmental protection and our corporate guidelines, we supply all lead-acid batteries to the secondary lead smelter at the Hoppecke site.

The HOPPECKE metal smelter is the only lead smelter in Europe to be successfully certified according to:

- DIN EN ISO 9001 (Procedures and Procedures)
- DIN EN ISO 14001 (Environmental Audit)

- Waste Management Company Ordinance for Waste Management Specialist with all associated waste codes for storage, treatment and recycling.

For more information, please call: +49(0)2963 61-280.

## 3.3 Service

HOPPECKE has a worldwide service network that you should take advantage of. The HOPPECKE service is available to you if you would like to have professional supervision during the installation of the battery system, if you need parts or accessories or if maintenance work must be carried out on the system. Please contact us or your local HOPPECKE contractual partner about this.

The HOPPECKE service number is:
Phone +49(0)800 246 77 32
Fax +49(0)2963 61-481
E-Mail service@hoppecke.com

## 3.4 Warranty

Commissioning and maintenance must be documented. For this, you can use our template, which you can find here:

service_maintenance_comissioning_protocoll_en_de.pdf (hoppecke.com)

or via the QR code:

Alternatively, you can use your own templates, as long as they contain the necessary data fields. This documentation should be kept together with the other battery documentation.

Note: Acid density fields are not required for VRLA (sealed lead-acid batteries) products and can be left empty.

For warranty claims, the documentation must be submitted to the manufacturer. Battery performance and service life, especially in terms of charging, temperature and cycles, affect the warranty. The customer/battery operator must prove that the parameters were within the recommended ranges. The protocols must be made available to the manufacturer. The service life only applies under optimal conditions.

HOPPECKE recommends the use of a stationary battery monitoring system. For more information, please contact your local HOPPECKE representative.

**Information about sun | power batteries**

For special applications, such as solar and off-grid applications, the service life is strongly influenced by the operating factors. In order to determine whether a battery fault has been caused by manufacturing defects or operation, the parameters must be recorded and secured regularly. This data must be forwarded to the manufacturer for analysis.

## 3.5 References to the standards and regulations

The references to the applicable standards, regulations, etc. should help you to install and use the HOPPECKE products correctly. However, it is not possible to always cite all regulations and applicable standards according to the current edition. Therefore, these instructions are to be understood as support and not as direct instructions. In order to implement the requirements of the standards/regulations, the current and applicable standard or regulation must be available, regardless of the edition of the standard/regulation manually quoted here in HOPPECKE.

Please note the following regulations (IEEE standards only apply to the USA):

- ZVEI publication “Instructions for the safe handling of electrolyte for lead-acid accumulators”
- VDE 0510 Part 2: 2001-12, in accordance with IEC 62485-2: “Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries”
- DIN EN 50110-1 (VDE 0105-1): “Operation of electrical installations”; German version EN 50110-1:2004
- IEEE Standard 485-1997: “Recommended Practice for Sizing Large Lead Acid Storage Batteries for Generating Stations”
- IEEE Standard 1187-2002: “Recommended Practice for Installation Design and Installation of Valve Regulated Lead-Acid Storage Batteries for Stationary Applications”
- IEEE Standard 1188-2005: “Recommended Practice for Maintenance, Testing and Replacement of Valve Regulated Lead-Acid (VRLA) Batteries for Stationary Applications”
- IEEE Standard 1189-2007: “Guide for Selection of Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications”
- IEEE Standard 1375-1998: “Guide for Protection of Stationary Battery Systems”

When working on batteries, always observe the safety regulations documented in DIN EN 50110-1 “Operation of electrical installations”:

    - Always proceed in the correct order when installing and removing the battery and when connecting it to the charger
    - Pay attention to polarity.

- Make sure that the connections are tight.
- Only use technically flawless charging cables in sufficient cross-sections.
- Batteries must not be connected or disconnected while power is flowing, or the charger is on.
- Before opening the charging circuit, check the switched off state of the charger by voltage measurement.
- Secure the charger against reconnection.
- Observe the operating instructions of the charger manufacturer.

## 3.6 CE and UKCA marking

For batteries that cover a voltage range of 4 V to 1500 V DC, a CE declaration of conformity is required in accordance with the Battery Regulation EU 2023/1542. In addition, the requirements of the Low Voltage Directive 2014/35/EU must be observed for battery systems with a nominal voltage of 75 V to 1500 V DC. The labelling requirement also applies to the UK, but the associated declarations of conformity must bear the UKCA mark by 31.12.2024 in accordance with The Electrical Equipment (Safety) Regulations 2016. The installer of the battery system is responsible for issuing the CE or UKCA declaration and affixing the CE or UKCA marking on or next to the battery's nameplate.

Use the QR code or this link to access the performance and lifetime data provided in accordance with Battery Regulation EU2023/1542 (Attachment IV, Part A):

# 4 Transport

## 4.1 General information

We pack the batteries that are shipped with the greatest possible care so that they arrive undamaged. Nevertheless, we strongly recommend that you inspect the delivery immediately upon arrival for any transport damage.

Filled lead-acid batteries are not treated as dangerous goods during road transport if:

- They are undamaged and leak-proof
- They are protected against falling over, slipping and short circuits
- They are firmly bound to a pallet
- There are no dangerous traces of acid or alkali etc. on the outside of the package

Danger!

**When transporting trucks, careful load securing is essential!**

Attention!

Block batteries/cells have a high weight (depending on the type between approx. 3 kg and max. 1100 kg per cell/block), please use safety shoes. Use only suitable transport equipment for transport and assembly!

## 4.2 Delivery completeness and externally visible damage

Check the delivery for completeness immediately after arrival, while the carrier is still present, using the delivery note. Pay special attention to the number of battery pallets and the boxes with accessories. Then check the goods for possible transport damage.

Make a note if necessary

- Damage to the outer packaging
- Visible stains or moisture that could indicate leaked electrolytes

In the event of incomplete delivery or transport damage

- Write a short defect report on the delivery note before signing it
- Ask the carrier for an audit and make a note of the name of the examiner
- Write a defect report, which you will forward to us and the forwarding company within 14 days

## 4.3 Defects

Take all necessary safety measures to avoid electric shock. Remember that you are handling energized batteries!

Unpack the goods as soon as possible after delivery and check them for defects, especially if commissioning is planned soon.

Check the entire scope of delivery using the detailed delivery note (or packing list). If defects or incompleteness are reported to the carrier too late, this may result in the loss of your claims. If you have any questions in connection with incompleteness of the delivery or damage to the delivered products, please contact your local HOPPECKE contractual partner. Alternatively, you can reach us directly at the head office.

# 5 Storage

## 5.1 General information

After receiving them, you should unpack, install and charge the batteries as soon as possible. If this is not possible, store the batteries in a fully charged state in a clean, dry, cool and frost-free room and do not expose the batteries to direct sunlight. During storage, batteries lose capacity due to self-discharge. High storage temperatures increase self-discharge and reduce the permissible storage time.

Attention!

Do not stack the pallets with the batteries, as this may cause damage that is not covered by the warranty.

## 5.2 Storage time

Attention!

The Figure 5.2-1 shows the relationship of the available capacity over the storage time, as well as the maximum storage time for different storage temperatures. When calculating the exact time, use the commissioning date in production (according to the imprint on the block/cell). In order to prevent damage, the batteries must be recharged in accordance with chap. 5.3 .
Failure to observe this can lead to sulphation of the electrodes and consequently to a loss of performance and a shorter service life of the battery. Recharging during the storage period should be done a maximum of two times. The battery must then be operated in constant charge maintenance. The useful life of the battery(s) begins with delivery from the HOPPECKE factory. Storage times on site are to be fully credited towards the useful life.

grid | power VX (GroE) must be recharged after 6 weeks when stored @20 C. The calculation of the maximum storage time for deviating temperatures is analogous to the Figure 5.2-1.

For unfilled cells/blocks, a maximum storage period of 24 months should not be exceeded.

If a longer storage period (e.g. several months) is planned, it is recommended that you obtain a suitable charger in good time so that the above-mentioned recharging can be carried out. The batteries should be arranged in such a way that they can be provisionally connected in series for charging. Leave them on their pallets until they are finally installed.
If batteries need to be cleaned during storage, never use detergents, but cotton cloths soaked in water without additives.
Failure to comply with the recharging intervals voids the warranty claim.

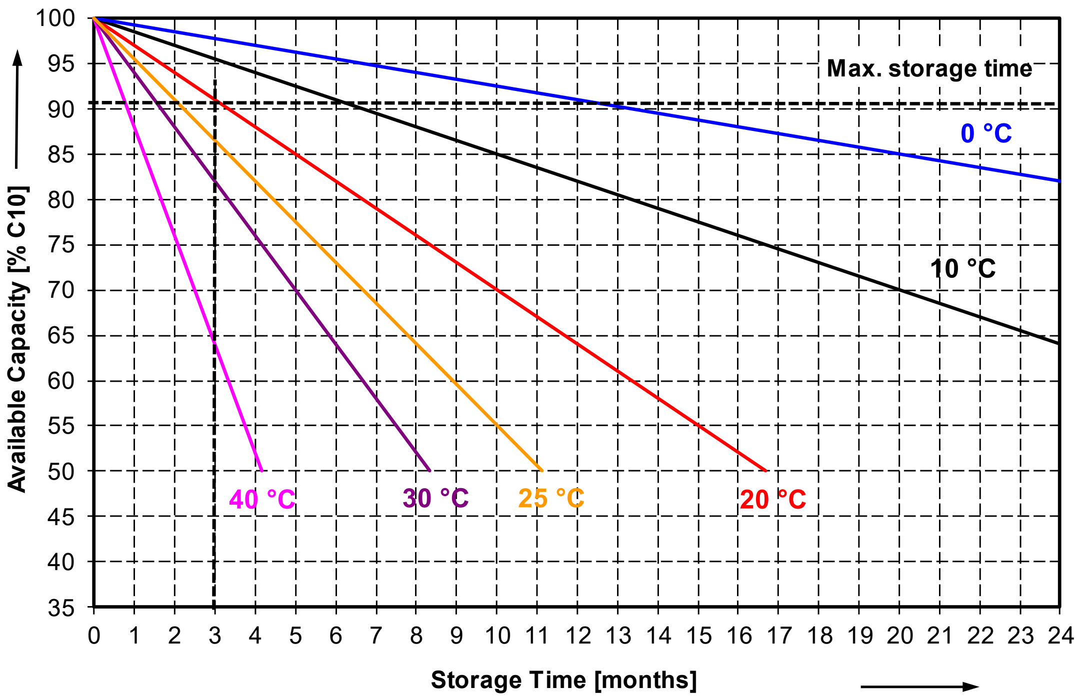



*Figure 5.2-1 Capacity over storage time*

## 5.3 Recharge

Perform the recharge as follows:

1. The permissible temperature range for recharging is 15°C to 35°C.
2. Charging with IU characteristic curve, up to max. 2.40 V/cell up to 24 hours. The charging current must not be higher than 20 A per 100 Ah nominal capacity.
3. When charging temporarily connected batteries, make sure that there is sufficient ventilation (see chap. 6.1.1).

Attention!

If the maximum storage time is exceeded and/or at higher average storage temperatures, charge acceptance may be more difficult during recharging. In such cases, HOPPECKE recommends the use of an advanced charging method that ensures gentle and complete recharging of the blocks/cells.

**Advanced charging method:**
Charge with const. current of 1 A or 2 A per 100 Ah $C_{10}$ battery capacity. Termination of the charge when all cell voltages have risen to at least 2.60 V/cell.

# 6 Installation

## 6.1 Requirements for the installation site

If you have any questions about the installation of the battery system, please contact your local HOPPECKE dealer. Alternatively, you can reach us directly at the head office.

When determining the installation location and space requirements and when carrying out the installation work, please refer to the valid installation drawing, if available. The floor must be suitable for the installation of the batteries, i.e:

- Suitable load capacity
- Electrolyte-resistant installation surface (otherwise use of acid drip trays) with vented batteries
- Sufficient conductivity of the floor against the grounded point, measured according to IEC 61340-4-1:
    - for a nominal voltage of the battery ≤ 500 V: 50 kΩ ≤ R ≤ 10 MΩ
    - for a nominal voltage of the battery > 500 V: 100 kΩ ≤ R ≤ 10 MΩ
- At ground level
- As vibration-free as possible (otherwise the use of special racks is necessary)

Within the EU, follow VDE 0510-485-2: April 2019, corresponding. IEC 62485-2 "Safety requirements for batteries and battery installations – Part 2: Stationary batteries".

*Table 6.1-1 - Installation site requirements*

| Request | Our recommendation |
|---|---|
| Ventilation | Danger! Sufficient room ventilation is absolutely necessary to keep the hydrogen concentration ($H_2$ concentration) in the room air of the battery room at a value < 4% by volume.<br>Hydrogen is lighter than air! It is imperative to ensure that hydrogen accumulation (e.g. in the ceiling area) cannot occur. Ventilation openings should therefore be installed in the immediate ceiling area. |
| Environment | The environment must be clean and dry. Water, oil and dirt residues on the cell surface must be avoided and, if necessary, removed immediately. |
| Aisle width/ minimum distances | See IEC 62485-2 |
| Access door | Lockable and fire retardant (T90). |
| Lighting | Recommendation: at least 100 lx. |
| Marking | Warning signs corresponding. IEC 62485-2. |

| | |
|---|---|
| |  Warning of electrical voltage is only necessary if battery voltage is > 60 V DC. |
| Danger of explosion | No ignition sources (e.g. open flames, bulbs, electrical switches, sparks) in the vicinity of the cell openings. |
| Ambient temperature | The specified operating temperature is 20 °C (based on IEC 60896). Higher temperatures shorten the service life. All technical<br>Dates apply to the nominal temperature of 20 °C. Lower temperatures reduce the available capacity. Exceeding the limit temperature of 55 °C is not permitted. Continuous operating temperatures of 45 °C or more must be avoided. Batteries must not be exposed to direct sunlight or other heat sources. |
| Ambient air | The air in the battery compartment must be free of contaminants, such as suspended solids, metal particles or flammable gases.<br>The humidity should be a maximum of 85%. |
| Insulation resistance | The minimum insulation resistance between the battery circuit and other local conductive parts must be greater than 100 Ω per volt (the nominal voltage of the battery). |
| Earthing | If the racks or battery cabinets are to be grounded, there must be a connection to a reliable earthing point. |
| Accommodation of the batteries | We recommend the proper installation of the batteries in HOPPECKE battery racks or cabinets. The use of operator-owned solutions may void the warranty for batteries. |
| Country-specific. regulations | In some countries, it is mandatory that racks with the batteries be installed in drip trays. Please observe the local regulations and, if necessary, contact your local HOPPECKE contractual partner. |

### 6.1.1 Ventilation of the battery room

It must be ensured that the requirements of IEC 62485-2 regarding installation and ventilation are complied with. If, during commissioning charging, the charging current is higher than the current used as a basis for the design of the ventilation equipment, the ventilation of the battery room must be increased for the duration of commissioning and for one hour thereafter in accordance with the charging current used, e.g. by means of portable auxiliary fans. The same applies to occasional special charging treatments of batteries.

### 6.1.1.1 Avoidance of explosion hazards

As the gases produced when charging batteries cannot be avoided, the hydrogen concentration must be diluted by sufficient ventilation. Spark-generating equipment is not permitted in the vicinity of batteries.

**Ignition sources for oxyhydrogen explosions can be:**

- Open flame
- Flying sparks
- Electrical, spark-forming equipment
- Mechanical, spark-forming equipment
- Electrostatic charge

**Measures to prevent oxyhydrogen explosions:**

- Adequate natural or forced ventilation
- No heating with an open flame or incandescent body (T > 300 °C)
- Separate battery compartments with separate ventilation
- Antistatic clothing, shoes and gloves (in accordance with the currently valid DIN EN 1149-1)
  - Surface leakage resistance < $10^8$ Ω and insulation resistance ≥ $10^5$ Ω
- Hand lamps with mains cable without switch (protection class II)
- Or hand lamps with battery (IP54 protection)
- Warning and prohibition signs

The ventilation requirements for battery compartments, cabinets or compartments result from the required dilution of the hydrogen produced during charging and the safety factors, which include the aging of the battery and the possibility of failure ("worst case").

### 6.1.1.2 Calculating Ventilation Requirements for Battery Rooms

**Air Volume Flow Q:**

$$Q = v \times q \times s \times n \times I_{Gas} \times \frac{C}{1000Ah}$$

$v$ = Dilution factor = 96 % air / 4 % H2 = 24

$q$ = Amount of hydrogen produced = 0.42 10–3 m3/Ah hydrogen produced at 0°C (**Note:** For calculations at 25 °C, the value q for 0 °C must be multiplied by a factor of 1.095.)

$s$ = Safety factor = 5

$n$ = Number of cells

$I_{Gas}$ = Gassing current per 100 Ah

$\boldsymbol{C}$ = Nominal capacity of the battery

**Summary of factors:**

$$\boldsymbol{v \times q \times s = 0,05}$$

$$\boldsymbol{Q = 0,05 \times n \times I_{Gas} \times \frac{C}{1000Ah}\ mit\ Q\ in \frac{m^3}{h}, I_{Gas}\ in\ A}$$

$$\boldsymbol{I_{Gas} = I_{float}\ bzw. I_{boost} \times f_g \times f_s}$$

*Table 6.1-2 - Indicative values for current (extract from IEC 62485-2)*

| **Parameter** | **Lead-acid batteries vented cells Sb < 3 % (antimony content in the positive grid < 3 %)** | **Lead-acid batteries VRLA cells** |
|---|---|---|
| $\boldsymbol{f_g}$: Gas emission factor | 1 | 0,2 |
| $\boldsymbol{f_s}$: Safety factor for gas emission (includes 10% defective cells and aging) | 5 | 5 |
| $\boldsymbol{U_{float}}$[1]: Float charge voltage, V/cell | 2,23 | 2,27 |
| $\boldsymbol{I_{float}}$: Typical float charge current, mA per Ah | 1 | 1 |
| $\boldsymbol{I_{Gas}}$[2]: Current (float charging), mA per Ah (refers only to the calculation of the air volume flow in float charging) | 5 | 1 |
| $\boldsymbol{U_{boost}}$: Boost charge voltage, V/Cell | 2,4 | 2,4 |
| $\boldsymbol{I_{boost}}$ Typical boost-charge current, mA per Ah | 4 | 8 |
| $\boldsymbol{I_{Gas}}$[2]: Current (boost charging), mA per Ah (refers to the calculation of the air volume flow during boost charging) | 20 | 8 |

[1] Float and boost-charge voltages may vary depending on the specific electrolyte density in lead-acid batteries.

[2] When using grid | AquaGen recombination systems (only with vented lead-acid batteries), the current $I_{gas}$ can be reduced to 50%.

For the ventilation design of battery compartments, "natural ventilation" or "forced ventilation" can be used as a basis depending on the structural conditions.

The following points should be noted:

**Natural ventilation:**

- Supply and exhaust air openings required
  - Openings on opposite walls
  - Minimum separation distance of 2 m when openings on the same wall
- Minimum cross-section each (Air inlet / outlet): $A \geq 28 \times Q \ \left(A\ in\ cm^2, \mathrm{Q\ in}\ \frac{m^3}{\mathrm{h}}\right)$
  Assumption: $v_{Luft} = \ 0{,}1\ \frac{\mathrm{m}}{\mathrm{s}}$
- Ventilation to the outside (not in air conditioning or adjacent rooms)

**Forced (artificial) ventilation:**

- Increased ventilation with fan (usually suction fan)
- Air flow rate according to the air volume flow $Q$
- The air sucked in must be clean, Requirements for the installation site
- When charging with heavy gassing, fan run-on of 1 hour is required
- If there are several batteries in a room, the following applies: Air requirement = $\sum Q$
- Prevention of a ventilation short circuit due to sufficient distance between the supply and exhaust air opening
- The ventilation system must be coupled with charger to ensure necessary airflow at all times

### 6.1.2 Calculating the safety distance

In the vicinity of batteries, the dilution of explosive gases is not always guaranteed. Therefore, a safety distance must be maintained through an air section in which no sparking or glowing equipment must be present (max. surface temperature 300 °C). The spread of the explosive gases depends on the amount of gas released and the ventilation in the vicinity of the gas source. The following equation can be used to calculate the safety distance "d" from the gassing source, assuming a hemispherical spread. The safety distance d can also be read from Figure 6.1-1. The more detailed calculations are shown below.

**Safety:**

The required safety distance must be calculated in accordance with IEC 62485-2.

Volume of a hemisphere:

Air volume flow required to dilute the produced hydrogen $H_2$ to max. 4% in the air:

**Required radius of hemisphere:**

$$V_h = \frac{2}{3} \times \pi \times d^3$$

Air volume flow required to dilute the produced hydrogen $H_2$ to max. 4% in the air:

$$Q_{Gas} = 0{,}05 \times \langle n \rangle \times I_{Gas} \times C \times 10^{-3} \left(\frac{m^3}{h}\right)$$

$$Q_{Gas} = \frac{V_h}{t}$$

**Required radius of hemisphere:**

$$d = 28{,}8 \times (\sqrt[3]{n} \times \sqrt[3]{I_{Gas}} \times \sqrt[3]{C}\ (mm)$$

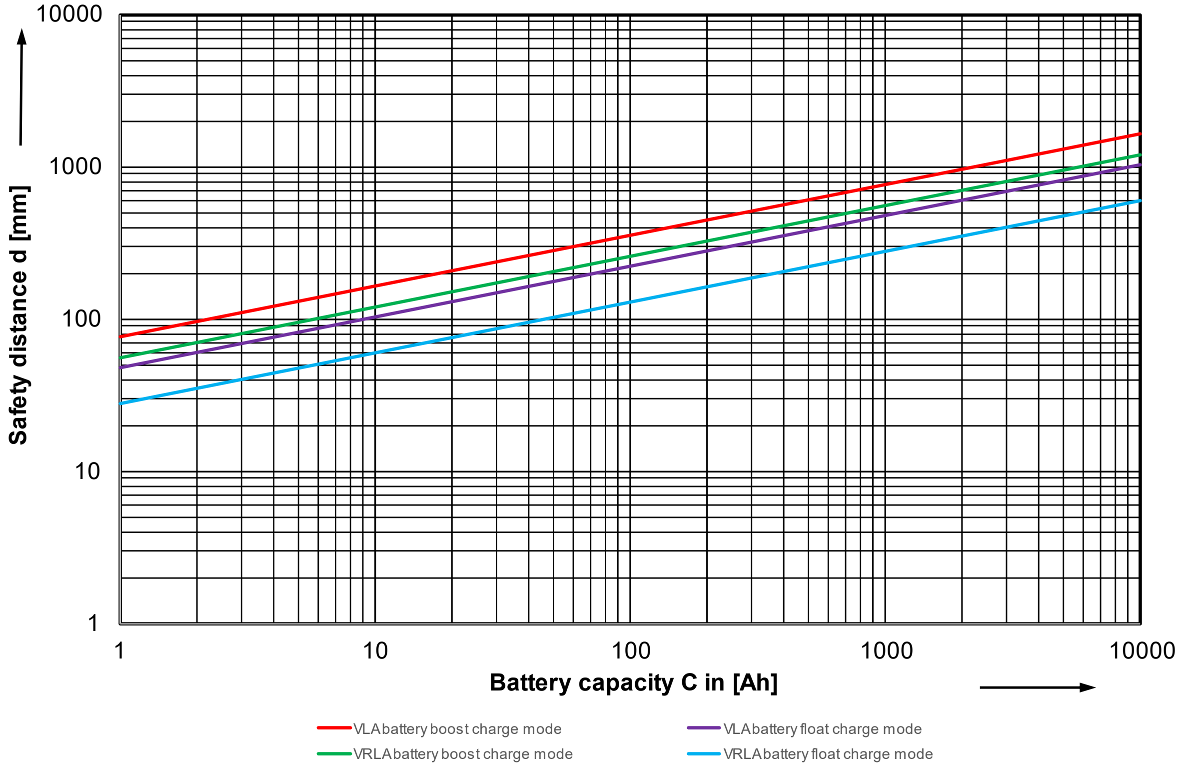



*Figure 6.1-1 - Safety distance depending on battery capacity*

## 6.2 Tools and equipment to carry out the installation

The batteries are delivered on pallets, and the necessary accessories are included in separate packaging units. Please note all the information from the previous chapters.

For the installation, you will need your personal protective equipment, safety clothing, safety tools and other equipment, as described in chap. 2.4 .

- Lifting trucks (forklifts, pallet trucks or small mobile cranes or similar to facilitate battery assembly)
- Chalk line and chalk (optional)
- Plastic spirit level (optional)
- Torque wrench
- Supporting elements for aligning the racks (cabinets) (optional)
- Ratchet box (optional)

- Set of open-end wrenches and ring wrenches with insulated handles
- Screwdriver with voltage-insulated handle
- Wiping paper or cloth (made of cotton; do not use synthetic fiber cloths as there is a risk of static electricity), moistened with water
- Tape measure made of plastic
- Safety equipment and clothing
- Aeronix® battery terminal grease (only for cells/blocks with exposed lead poles)
- Insulating mats for covering conductive parts

## 6.3 Commissioning and maintenance protocol

This must be documented as proof that commissioning and maintenance have been carried out correctly. Alternatively, you can use your own templates for documentation. In any case, these should contain the necessary data/data fields. The documentation of commissioning and maintenance should be kept together with the other documentation of the battery/battery system.

Note: The following template contains fields for documenting acid density – these fields are not used for VRLA (sealed lead-acid batteries) products and can therefore be left blank.

The log can be downloaded as an extra file at:

service_maintenance_comissioning_protocoll_en_de.pdf (hoppecke.com)

or use the QR code:

This documentation must be submitted to the manufacturer as proof in the event of warranty claims.

## 6.4 Installing racks and cabinets

We recommend the proper installation of the batteries in HOPPECKE battery racks or HOPPECKE battery cabinets. If operator-owned solutions are used, the warranty of the battery(s) may expire. HOPPECKE supplies various types of racks. For information on the assembly, please also refer to the separate documentation that comes with each rack.

*Figure 6.4-1 – Tier rack (left) and step rack (right)*

1. Using the installation drawing (if available), mark the outlines of the racks on the installation surface with chalk.
2. The installation surface must be level and load-bearing.
3. Set up the racks on a trial basis and align them horizontally.
4. Adjust the spacing of the support rails to match the cell or block battery dimensions.
5. Check the stability of the frames and all screw or clamp connections for tight fit.
6. Ground the racks or frame parts (if provided).

When using wooden frames: Install a flexible connection on each frame joint!

As an alternative to installation in racks, the batteries can also be installed in HOPPECKE battery cabinets. Either the cabinets are delivered with batteries already installed or the batteries are installed in the cabinets on site. HOPPECKE supplies various types of cabinets.

When installing block batteries with L-connectors, it should be noted that the L-connectors must be installed before being placed in the battery cabinet.
**Note:** The L-connectors are not intended for high-current (UPS) applications. Ask your local HOPPECKE representative about this.

## 6.5 General information on connecting the batteries

Attention!

When connecting the batteries, always form the series connections first and then the parallel connection. A reverse approach is not permitted. Check the batteries for correct polarity before wiring.

To form the series connections, the batteries are arranged in such a way that the positive pole of one battery is as close as possible to the negative pole of the next battery.

When connecting stationary batteries in parallel, the following points must be observed:

1. Only battery strings of the same length and voltage should be connected to each other. Cross-connections of the individual strands between cells or blocks should be avoided, as they mask bad or faulty cells/blocks and can thus be the cause of overcharging of individual battery strands.
2. Only batteries of the same type and the same state of charge should be connected (same battery type, plate size and plate construction).
3. The environmental conditions for all strings connected in parallel should be identical. In particular, temperature differences between the individual strings/batteries must be avoided.
4. In order to ensure uniform current distribution, the connectors and end connections should be designed in such a way that there are equal resistance ratios in the individual feeds to the consumer.
5. The commissioning date of the batteries should be identical (batteries of the same age, the same service life and the same state of charge).
6. Depending on the application and system voltage, the number of parallel switched battery strings as follows:

a.) Cyclic operation:

| | |
|---|---|
| Batteries $\leq 48\ V$ | max. 4-6 strings (max. 10 strings – grid \| Xtreme VR) |
| Batteries $> 48\ V$ | max. 2 strings (max. 4 strings – grid \| Xtreme VR) |

**Note:** Since the charge factor is usually low in cyclic applications, the risk of insufficient charging increases if the previously mentioned maximum number of parallel battery strings is exceeded.

b.) Standby parallel operation:

| | | |
|---|---|---|
| Batteries $\leq 60\ V$ | grid \| Xtreme VR $\leq 230\ V$ | max. 8-10 strings |
| Batteries $> 60\ V$ | grid \| Xtreme VR $> 230\ V$ | max. 6 strings |

In special cases, consultation with Hoppecke is necessary.

If the above points are not met, the strings must be charged separately before the parallel connection is carried out.

## 6.6 Installing the batteries

The greatest care must be taken when lifting and moving the batteries, as a falling battery can cause personal injury and material damage. Be sure to wear safety shoes and safety goggles. Always lift batteries only from below and never at the poles, as this will result in the destruction of the battery. Check the batteries for perfect condition before installation (visual inspection). When installing the batteries, VDE 0510-485-2: April 2019 (in accordance with IEC 62485-2) must be observed. For example, electrically conductive parts must be covered with insulating mats.

### 6.6.1 Inserting batteries into the racks

1. Apply some soft soap to the support rails of the frame to make it easier to move the batteries sideways after they have been put down.

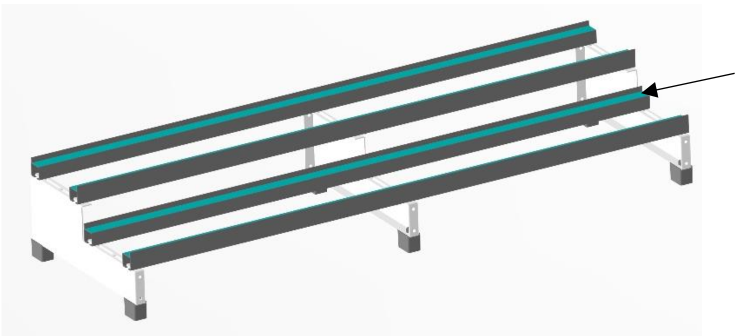


*Figure 6.6-1 - Treatment of the support rails*

2. Position the batteries in the racks one after the other at the correct angle and with the correct polarity and remove all transportation and lifting aids.

For large batteries, it is convenient to start by mounting them in the middle of the rack. If you are using racks with tiers, first mount the lower level.

Attention! Carefully place the batteries on the support rails of the frame, otherwise the battery housing may be damaged. When setting down the batteries, avoid at all costs that they collide with each other. Risk of battery destruction!

Danger! The positive and negative terminals of a cell or block must not be short-circuited under any circumstances. This also applies to the positive and negative terminals of the entire battery or battery string. Be careful, especially when using step racks!

3. Move the blocks (or cells) sideways until the distance is about 10 mm. If connectors are used, they specify the distance. When moving the batteries sideways in the rack, do not press in the middle, but in the area of the (stiffer) corners. Only press by hand, never use tools!
4. Finally, count all cells/block batteries and check that the installation is complete.

### 6.6.2 Procedure for filled batteries

#### 6.6.2.1 Carry out open-circuit voltage measurement

Before you finally install the GUG (Filled and Charged) batteries, carry out an open-circuit voltage measurement of the individual cells or block batteries to determine their state of charge and function. The decisive criterion here is that the open-circuit voltages of the individual battery cells do not differ from each other by more than 0.02 V.

The following maximum deviations of the open-circuit voltage between the cells apply to block batteries:

- 4 V Block battery: 0.03 V/Block
- 6 V Block battery: 0.04 V/Block
- 12 V Block battery: 0.05 V/Block

In the event of larger deviations in the cell voltage between each other, it is necessary to consult your local HOPPECKE contractual partner.

As a guide to the open-circuit voltage, the open-circuit voltage ranges for fully charged cells at an electrolyte temperature of 20°C are shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**. Depending on the time of the last recharge, which is largely determined by the logistics times, the measured values may also be lower due to the natural self-discharge of the battery.

*6-1 Expected open-circuit voltage in the full charge state for different cells/block batteries*

| Type of cell/block battery | Open circuit voltage |
|---|---|
| grid \| power V X | (2.06 ± 0.01) V/Z |
| grid \| power V L | (2.08 ± 0.01) V/Z |
| grid \| power V H bloc | (2.08 ± 0.01) V/Z |
| grid \| power V M | (2.08 ± 0.01) V/Z |
| grid \| power V H | (2.11 ± 0.01) V/Z |
| sun \| power V L | (2.08 ± 0.01) V/Z |

Higher temperatures decrease, lower temperatures increase the open-circuit voltage. If there is a deviation of 15 K from the nominal temperature, the open-circuit voltage changes by 0.01 V/cell.

If the open-circuit voltage is low during storage, the battery should either be recharged as described in chap. 5.3 or put into operation as described in the chap. 6.7. In the event of major deviations, it is necessary to consult your local HOPPECKE contractual partner.

#### 6.6.2.2 Electrolyte level

In the case of GUG batteries (Filled and Charged), the electrolyte level in the delivery state may be below the maximum mark. However, this does not constitute a defect, as the level rises again during the commissioning process and the associated gassing. If the electrolyte level is still below the maximum mark after commissioning, follow the instructions in chap. 6.8.

### 6.6.3 What to do in case of unfilled batteries

#### 6.6.3.1 Filling cells

If the cells/batteries were delivered in a dry (unfilled) state, they are now filled.

Acid containers that have been emptied, but not completely emptied and cleaned, are considered filled within the meaning of the GGVS (Road Dangerous Goods Ordinance) and within the meaning of the Waste Ordinance. If acid canisters are to be disposed of, the applicable legal regulations for disposal in the country of destination must be observed. Please also note the disposal and treatment suggestions in the safety data sheet on sulfuric acid.

#### 6.6.3.2 Filling process

Before filling the cells, ensure that the specifications of IEC 62485-2 regarding installation and ventilation, listed in chap. 6.1, are observed.

The filling acid with the density according to must comply with the purity requirements according to IEC 62877-1. The cells are to be filled to the lower electrolyte level. Acid-resistant filling devices (funnels), but not made of stainless steel, must be used. The plugs already fitted to the batteries are HOPPECKE labyrinth plugs. These plugs, or the alternative variants listed in chap. 6.6.4 must remain on the batteries after the cells have been filled and during regular operation. To increase safety and reduce maintenance costs, we recommend using the HOPPECKE grid | AquaGen pro recombination system.

Higher temperatures decrease, lower temperatures increase the electrolyte density. The corresponding correction factor is 0.0007 kg/l per K.

Example: Electrolyte density 1.23 kg/l at 35 °C corresponds to a density of 1.24 kg/l at 20 °C.

#### 6.6.3.3 After completion of the filling process

After filling the cells, a standing time of 2 hours must be observed in each case. Immediately afterwards, depending on the total number, the temperature and density of the electrolyte must be measured on at least 4 to 8 cells (pilot cells) and recorded in the commissioning report. (see chap. 6.3). If the temperature rise is less than 5 K and the electrolyte density has not fallen below the density of the filling acid by more than 0.02 kg/l, a simplified commissioning charge in accordance with chap. 6.7 is sufficient. If one of the deviations is greater, an extended commissioning charge is required in accordance with chap. 6.7.3. During the downtime, the further installation process can be continued.

Attention!

The commissioning charge must be carried out immediately after the standing time of the last filled cell has been reached.

*6-2 Electrolyte density in kg/l at 20 °C*

| **Series** | **Filling density kg/l** | **Nominal density kg/l** |
|---|---|---|
| grid \| power V X | 1,21 | 1,22 |
| grid \| power V L | 1,23 | 1,24 |
| grid \| power V H (OGi bloc) | 1,23 | 1,24 |
| grid \| power V M | 1,23 | 1,24 |
| grid \| power V H | 1,26 | 1,27 |
| sun \| power V L | 1,23 | 1,24 |

### 6.6.4 Variants of plugs

This section describes the different variants of cell plugs. These plugs are included in the HOPPECKE accessories list and can also be retrofitted later if required.

#### 6.6.4.1 Labyrinth plugs (delivery condition)

The labyrinth plug prevents aerosols from escaping with the help of the internal labyrinth. In addition, the plug serves as an adapter for the grid | AquaGen pro (max) recombination plug.

*Illustration 6-2 - Labyrinth plug*

#### 6.6.4.2 grid | AquaGen pro (max) recombination plug

The recombination plug recovers water from the resulting oxyhydrogen gas through the recombining effect of a catalyst. This significantly reduces maintenance costs.

All relevant information is available in the corresponding grid | AquaGen pro (max) documentation.


*Illustration 6-3 - grid | AquaGen pro (max)*

#### 6.6.4.3 Ceramic and ceramic funnel plugs

Thanks to their porous ceramic body, **ceramic plugs** ensure better retention of acid aerosols and water vapor. They have a backfire-inhibiting effect.

*Illustration 6-4 - Ceramicsstopfen*

**Ceramic funnel plugs** have the same effect as the previously mentioned ceramic plugs. They also allow water to be topped up and electrolyte density and temperature to be measured when installed.

*Illustration 6-5 - Ceramic funnel plugs*

**Installation of the ceramic and ceramic funnel plugs**: After removing the labyrinth plugs, insert them into the cell opening and fasten them correctly.

Ensure that the sealing rings are firmly seated. During the periodic battery check, ensure that the ceramic bodies are clean. In the event of external contamination, e.g. with dust, clean with a dry brush. If the ceramic is more than one third wet, malfunctions may occur. The difficult passage caused by the wetting can lead to a build-up of pressure inside the cell, resulting in electrolyte leakage. To avoid these malfunctions, the ceramic plugs must be removed, thoroughly rinsed and then dried in a heated, dry room for approx. 6 days. During the cleaning period, the corresponding cells must be sealed with replacement plugs.

#### 6.6.4.4 Service plugs

HOPPECKE cell containers are equipped with service openings, which are sealed with a green EPDM plug (see illustration 6-1). This opening can be used for water refilling, electrolyte removal, acid density measurement and electrolyte temperature measurement. Especially in combination with the recombination plug grid | AquaGen pro, it is recommended to use this opening, as it is no longer necessary to remove the recombination plug. This saves time and minimizes the safety risk.

*6-1 Service Plugs*

### 6.6.5 Connecting batteries

The batteries are now in their final position and can be connected.

#### 6.6.5.1 Connection Terminals

The majority of closed batteries are equipped with connection terminals that have either a brass or copper terminal insert and a plastic coating. This eliminates the need for terminal grease.

For battery cells with partially exposed pole lead, the battery poles are greased at the factory with Aeronix® battery grease. This applies to the series:

- grid | power V X 2- 500 to 2600
- grid | power V M 6-50 to 200

Regardless the terminal design, it is important to check each individual terminal for damage or oxidation. If oxidation is visible on the surface of the terminal inserts, it is important to clean them before putting on the connectors and, if necessary, to regrease them with the original battery terminal grease. This is especially true in the case of visible oxidation of the terminal insert.

**More information about grid | power V X and grid | power V M**

In the case of battery cells without plastic-coated terminals, the supplied terminal cover rings must be placed around the terminals as touch protection. At grid | power V X make sure that the small recesses point downwards. The red ring is for the positive terminal and the blue ring for the negative terminal. For the neutral gray rings for grid | power V M, this requirement is irrelevant.

*Figure 6 - Pole cap grid | power V X*

#### 6.6.5.2 Type of connecting cables

The supplied battery system is designed to deliver a specified power (kW) or current (A) at a specified voltage (U) for a certain period of time (standby time). You should be familiar with these parameters (U, kW, A). If this is not the case, please contact your local HOPPECKE contractual partner. The battery system has been designed in such a way that the above performance characteristics are available on the battery terminals. The voltage drop between the battery terminals and the consumers should therefore be kept to a minimum. Too high a voltage drop can lead to a reduced standby time of the battery system.

Therefore, please note the following information:

1. The cable length between batteries and charging rectifier/UPS should be as short as possible.
2. The cable cross-section should be dimensioned in such a way that there is no significant voltage drop even with a large current flow. For this purpose, the voltage drop at nominal current should be calculated based on the intended cable cross-section. If in doubt, choose the next larger cable cross-section.

Danger!

The connecting cables between the end connection poles of the battery system and the battery fuses must be suitable for short-circuit-proof installation and must be laid in a short-circuit-proof manner. This means:

- Routing of cables with simple insulation in separate cable ducts
- Routing of cables with double insulation (e.g. H07RN-F, NSGAFöu) in a common cable duct
- Insulation strength of the cable is above the maximum possible system voltage
- Additional insulation of the connectors is required

- Avoidance of any mechanical stress on the cells or battery terminals. Cables with large cross-sections should be intercepted by cable clamps

The connecting cables between the main connection poles and the charging rectifier or UPS should be designed as flexible conductors.

### 6.6.6 Connect batteries to battery connectors

There are screwable row connectors, step connectors and tier connectors (cf. Figure 6.6.6-1). The row connectors are used to connect the individual cells/block batteries, the step connectors to connect the individual steps to each other (use of step racks) and the tier connectors to connect the tiers (use of floor racks).

*Figure 6.6.6-1 - Use of series and step connectors*

### 6.6.7 Installing the screw connectors

1. The cells or block batteries are connected by isolated row connectors (see Figure 6.6.7-1). The negative pole of a cell or block is connected to the positive pole of the next cell or block until the desired total system voltage is reached.

Attention!

Be careful not to mechanically damage the terminals.

2. Attach the connectors as described in Figure 6.6.6-1 shown. Tighten the screws by hand first to be able to align the cells and connectors again.
3. Tighten the screws with a torque wrench. The prescribed torque is 20 Nm ± 1 Nm.

Attention!

Exceptions:
Series power.com H.C:

- M5: 2 - 3 Nm
- M6: 4 - 5.4 Nm
- M8: 11 - 14 Nm

Series grid | Xtreme VR: 15 Nm

grid | power VM 2-105: 15 Nm
grid | power VM 6-50 and 6-100: 12 Nm
**Careful tightening of the connections is essential, as a loose connection can lead to excessive heating, which could result in ignition or explosion.**
**For tightening the pole bolts on block batteries of the grid- and sun | power VR L as well as grid and sun | power V L is to use a wrench size of 20 mm.**

4. If necessary, install insulating covers for the connectors and the end terminals (connection plates).

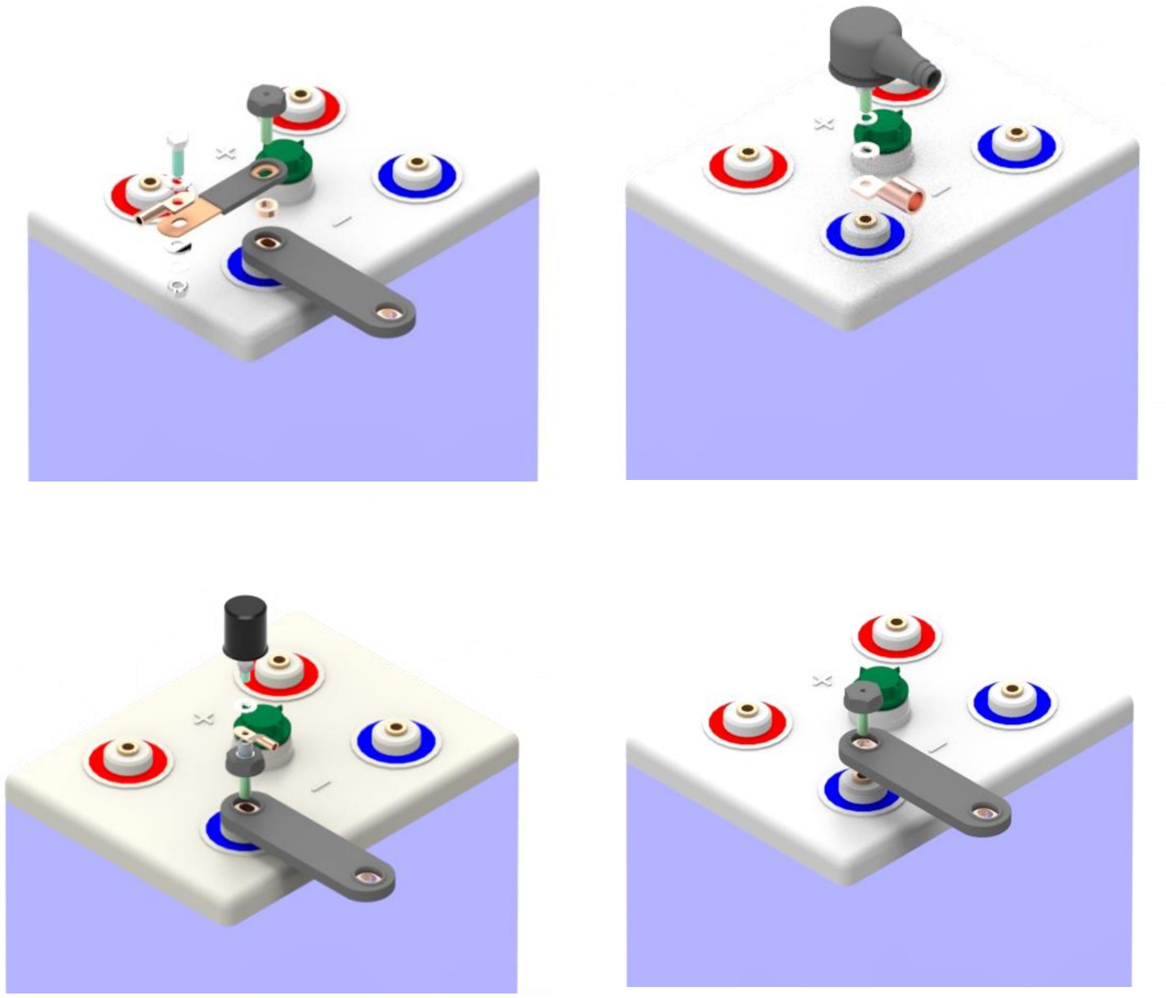


*Figure 6.6.7-1 - Pole connection options for voltage taps, monitoring and cable lugs for end connection*

## 6.6.8 Clamp the connection plates to the batteries

There are a total of 11 different types of connection plates (cf. Figure 6.6.8-1). Connection plates are always used when cables must be connected to cells with several battery terminals.

To connect the cables to cells with several pairs of battery terminals, the use of original HOPPECKE connection plates is strongly recommended. If other solutions are used, there may be a risk of overheating and fire due to increased contact resistance!

Attention!

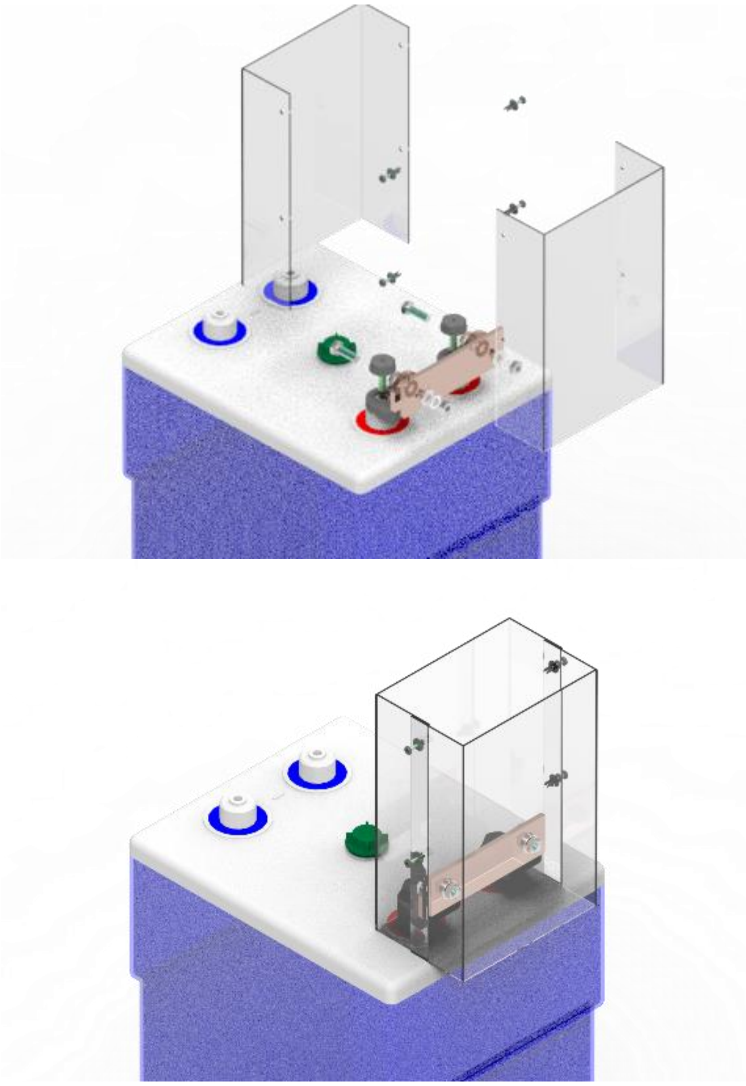


*Figure 6.6.8-1 - Mounting the terminal plate to the end terminals of the battery*

**Installation of standard connection plates**

1. Screw the connection bracket onto the end terminals of the battery (cf. Figure 6.6.8-1).

Be careful not to mechanically damage the terminals.

Attention!

2. Tighten the screws by hand first to be able to align the cells, connection brackets and connection plates again.
3. Screw the connection plate to the connection brackets with a torque of 20 Nm.

4. Then tighten the terminal screws with a torque wrench. The prescribed torque is 20 Nm ± 1 Nm.
   Exceptions:
   Series power.com H.C:
   - M5: 2 - 3 Nm
   - M6: 4 - 5.4 Nm
   - M8: 11 - 14 Nm

   Series grid | Xtreme VR: 15 Nm

   grid | power VM 2-105: 15 Nm
   grid | power VM 6-50 and 6-100: 12 Nm

Attention!

Careful tightening of the connections is essential, as a loose connection can lead to excessive heating, which could result in ignition or explosion.

### 6.6.9 Connect the battery system to the DC power supply

Attention!

Before connecting to the charging rectifier or to the UPS, it must be ensured that all assembly work has been completed properly!

1. Measure the total voltage (setpoint = sum of the open circuit voltages of the individual cells or block batteries).
2. If necessary: Provide the cells or block batteries with a continuous numbering in a visible place (from the positive terminal of the battery to the negative terminal). Number stickers are supplied by HOPPECKE.
3. Attach polarity plates to the battery connectors.
4. Fill in the nameplate in the maintenance and commissioning protocol (see chap.6.3) and keep this document with the battery system.
5. Attach the safety signs (these are: "Danger from batteries", "No smoking" and "Danger from voltage if battery voltage > 60 V"). If necessary, additional labels must be affixed in accordance with local regulations.
6. If necessary: Clean the batteries, the racks and the installation room.

Danger!

Never clean batteries with feather dusters or dry cloths made of synthetic fibres! Danger of electrostatic charge and oxyhydrogen explosion! We recommend using slightly damp cotton or paper towels for cleaning.

7. Connect the battery system to the charging rectifier or UPS via the end connections ("plus to plus" and "minus to minus").

The connecting cables between the end connections of the battery and the charging rectifier/UPS should be designed as flexible conductors. Rigid conductors can transmit vibrations, which may lead to the connection being loosened. The cables must be supported in such a way that no mechanical forces can be transmitted to the connection terminals (cable trays, cable ducts, cable clamps).

## 6.7 Commissioning charge (initial charge)

As a rule, the batteries are no longer fully charged at the time of installation. This applies in particular to batteries that have previously been stored for a long time (see chap. 5). To bring the cells to an optimal state of charge as quickly as possible, you should first carry out an initial charge. The first charge (time-limited) is a so-called "boost charge".

1. Find out what is the maximum voltage allowed that the charging rectifier can deliver without damaging the peripherals.

2. Divide this maximum value by the number of battery cells connected in series (i.e. not batteries). The value determined in this way is the maximum possible cell voltage for the initial charge.

3. Adjust the voltage so that average cell voltages of max. 2.40 V per cell result. The initial charge can take up to 72 hours.

4. It is important that the first charge is complete. This is only possible with a charging voltage greater than 2.35 V/cell. Interruptions are to be avoided as far as possible. The commissioning must be recorded in the commissioning report (see test report).

5. During commissioning, the cell voltage on the pilot cells and, after completion of commissioning, the cell voltage, electrolyte density and temperature on all cells must be measured and recorded in the commissioning report with time.

Alternatively, several types of commissioning charging are possible.

### 6.7.1 Commissioning charge with constant voltage (IU characteristic curve)

- A charging voltage of 2.35 to 2.4 V/cell is required
- The charging current at the beginning of the charge should be at least 5 A per 100 Ah $C_{10}$. The electrolyte density increases slowly during charging, so the charging time can take several days to reach a minimum electrolyte density of nominal electrolyte density - 0.01 kg/l
- Then switch to the float charge voltage according to the instructions for use
- The density of the electrolyte increases to the nominal value during operation

Danger!

If the batteries are put into operation with an IU charge, the following points must be considered:

- When the charging voltage of 2.35-2.4 V is reached, the strong gassing (electrolysis of the water) begins
- Due to the strong gassing, the risk of deflagration is very high

Therefore, the electrolyte density must not be measured in the boost-charge phase. Measuring the acid density in the boost-charge phase can lead to electrostatic discharge and the high hydrogen gas concentration can lead to deflagration.

Therefore, the following steps should be followed:

- Depending on the chemical condition of the cells/batteries, the U-phase can last between 24-72 hours
- After the boost charging phase (2.35-2.4 V), the charging voltage should be switched to float charge
- Wait at least 1 hour (degassing of the battery)
- Measurement of acid density
- If the nominal value of the acid density is not reached, the boost charging phase should be continued.

### 6.7.2 Commissioning charge with constant (I-characteristic curve) or decreasing current (W-characteristic curve)

The maximum permissible currents are shown in Tables 5-6.

| **Characteristic curve<br>I-characteristic** | **Charging current<br>5 A** |
|---|---|
| W-characteristic at | |
| 2.0 V/cell | 14 A |
| 2.4 V/cell | 7.0 A |
| 2.65 V/cell | 3.5 A |

Table 5-6: Maximum permissible charging currents in A per 100 Ah $C_{10}$ for I- and W-charging

Charging must continue until

- All cells have reached a voltage of at least 2.6 V
- The density of the electrolyte does not increase for a further 2 hours, please observe the second hazard warning in the chapter 6.7

Then switch to the float charge voltage as specified in the operating instructions.

### 6.7.3 Extended commissioning charge

The state of charge of the cells is reduced by long storage of UG (unfilled, charged) cells/batteries or by climatic influences (humidity, temperature fluctuations). This will require an extended commissioning charge.

Conduct the extended commissioning charge according to the following procedure:

1. Charging with 15 A per 100 Ah C10 to 2.4 V/cell (approx. 3 to 5 hours).
2. Charge for 14 hours with 5 A per 100 Ah $C_{10}$ (voltage exceeds 2.4 V/cell).
3. One hour break.

4. 4 hours of charging with 5 A per 100 Ah $C_{10}$

Repeat items 3 and 4 until all

- Cells have reached a voltage of at least 2.6 V
- The electrolyte density in all cells has risen to the nominal value of ± 0.01 kg/l and these values cease to rise for a further 2 hours, please note the second warning from the chapter. 6.7.

Then switch to the float charge voltage as described in chap. 7.2.3.

## 6.8 Electrolyte level check

If the electrolyte level of UG (unfilled, charged) cells/batteries is below the maximum mark after commissioning, sulfuric acid must be topped up to the upper electrolyte level mark. For GUG (filled and charged) cells/batteries, distilled water is used for refilling.

## 6.9 Electrolyte density adjustment

If the electrolyte density is too high at the end of commissioning, part of the electrolyte must be replaced by demineralized water in accordance with IEC 62877-1. The electrolyte density of the individual cells should not differ from each other by more than 0.01 kg/l. In the case of larger deviations, an electrolyte density adjustment with a subsequent compensating charge must be carried out in accordance with the instructions for use. The acid level must be adjusted to the upper electrolyte level mark.

# 7 Battery operation

## 7.1 Modes

Batteries can operate in different modes, each with specific characteristics and requirements. Each mode of operation has its own characteristics and operating conditions, which are explained in more detail below.

### 7.1.1 Standby parallel operation

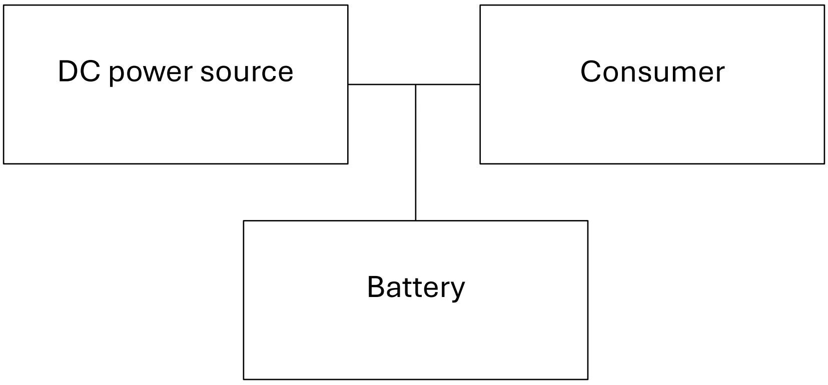



*Figure 7.1.1-1 - Standby parallel operation*

Characteristic of this mode of operation are:

- Consumer, DC power source and battery are constantly connected in parallel
- The charging voltage is the operating voltage of the battery and at the same time the system voltage
- The DC power source (charging rectifier) can deliver the maximum consumer current and battery charging current at any time
- The battery will only provide power if the DC power source fails
- The charging voltage to be set is the float charge voltage per cell x the number of cells connected in series (measured at the end poles of the battery)
- To shorten the recharging time, a charging stage can be used at which the charging voltage is max. 2.4 V x number of cells (standby parallel operation with recharging stage)

### 7.1.2 Floating operation

Characteristic of this mode of operation are:

- Consumer, DC power source and battery are constantly connected in parallel
- The charging voltage is the operating voltage of the battery and at the same time the system voltage
- The DC power source is not capable of always delivering the maximum consumer current. The consumer current temporarily exceeds the rated current of the DC power source. During this time, the battery provides power
- It is therefore not always fully charged
- Therefore, the charging voltage should be set to approx. (2.25 to 2.30 V) for vented lead batteries and approx. (2.27 to 2.32 V) for valve regulated lead batteries x the number of cells connected in series in consultation with the battery manufacturer, depending on the number of discharges

### 7.1.3 Switch mode operation (charge/discharge operation)

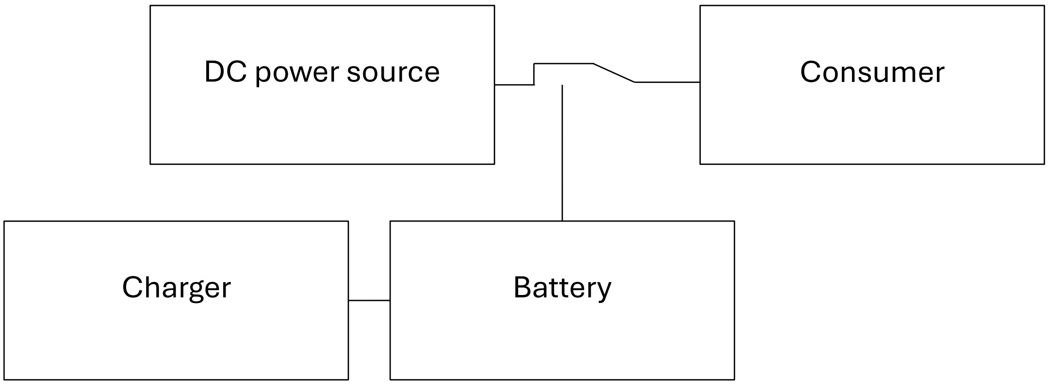



*Figure 7.1.3-1 - Switchover operation*

Characteristic of this mode of operation are:

- When charging, the battery is disconnected from the consumer
- **Vented lead-acid battery:**

  The charging voltage is 2.6 to 2.75 V/cell towards the end of the charge (depending on depth of discharge and number of cyclic loads)

  **Valve regulated lead-acid battery:**

  The charging voltage for sealed batteries is max. 2.4 V/cell
- The charging process must be monitored
- **Vented lead-acid battery:**

  After reaching the full charge state, the charge must be terminated or transferred to float charge in accordance with chap.7.2.3 .

  **Valve regulated lead-acid battery:**

  If the charging current at 2.4 V/cell has fallen to 1.5 A per 100 Ah nominal capacity switch to trickle charging in accordance with chap. 7.2.3
- The battery can be switched to the consumer as needed

## 7.2 General information on the operation

DIN VDE 0510 Part 1 and IEC 62485-2 apply to the operation of stationary battery systems. Every battery is subject to a natural electrochemical ageing process, which leads to a reduction in the internal discharge cross-sections of the battery in particular (corrosion). How quickly the ageing process progresses, and therefore the service life of the battery, depends largely on the operating temperature.

Attention!

The recommended operating temperature range for lead-acid batteries is 10°C to 30°C. The technical data apply to the nominal temperature of 20 °C. The ideal operating temperature range is 20 °C ± 5 K. Higher temperatures shorten the service life. Lower temperatures reduce the available capacity. Exceeding the limit temperature of 55 °C is not permitted. Continuous operating temperatures greater than 45 °C are to be avoided. (Exception: grid | Xtreme VR)

The natural aging process and thus the service life expectation play an important role, especially in the context of high-current applications. A high-current application is defined as currents and discharge rates of ≤ $C_{0.5}$. When discharging with high currents, disproportionately more heat is generated, which can lead to thermal overloading of the reduced discharge cross-sections. After a certain ageing progress, the reduced cross-sections are no longer able to conduct the current designed for the load case over the defined period. In extreme cases, this can lead to an unexpected failure of the battery.

**Permissible operating temperature ranges:**
Vented / VRLA batteries: -20°C to +40°C
grid | Xtreme VR batteries: - 40 °C to + 55 °C (with short peaks up to 60°)

When using the HOPPECKE grid | AquaGen recombination system in the context of vented batteries, the operating temperature of the recombination system must always be ≥ 5°C. This prevents icing on the internal ceramic components and ensures optimum recombination.

Attention!

Additional intervention in the charging regime, such as through a BMS, must be discussed with HOPPECKE.

### 7.2.1 Discharging

Attention!

The final discharge voltage of the battery assigned to the discharge current must not be undercut.
Unless specific information is provided by the manufacturer, no more than the nominal capacity may be withdrawn. After discharges (even partial discharges), fully charge the battery immediately.

### 7.2.2 Charging – General

Depending on the application, charging takes place in the operating modes listed in chap. 7.1.1 to chap. 7.1.3. The charging method is applicable with the limit values according to DIN 41773 (IU characteristic curve). The sun products are daily discharged and for this reason the charging profile of these products is different compared to the standby application. The charging parameter for the cyclic applications (sun products) are listed in chap. 11.

Attention!

**Superimposed AC currents**
Depending on the charger type and charging characteristic curve, alternating currents flow through the battery during charging and are superimposed onto the charging direct current. These super-imposed alternating currents and the reaction of the loads lead to additional heating

of the battery or batteries and create a cyclical strain on the electrodes. This might result in premature aging of the battery.

In order to achieve the optimum service life for vented batteries on float charge, a maximum effective value of the alternating current of 2 A per 100 Ah nominal capacity is recommended. During the boost charging the value of 10 A/100 Ah should not be exceeded.

Attention!

**Temperature-dependent adjustment of the charging voltage**
Temperature compensation of the voltage is necessary if the battery operating temperature deviates from 20 °C. Hoppecke recommends -4 mV/K. If the inverter cannot realize the compensation (technically), the border area would be 15 °C to 25 °C (see Figure 7.2.2-1). Nevertheless, the compensation should be realized.

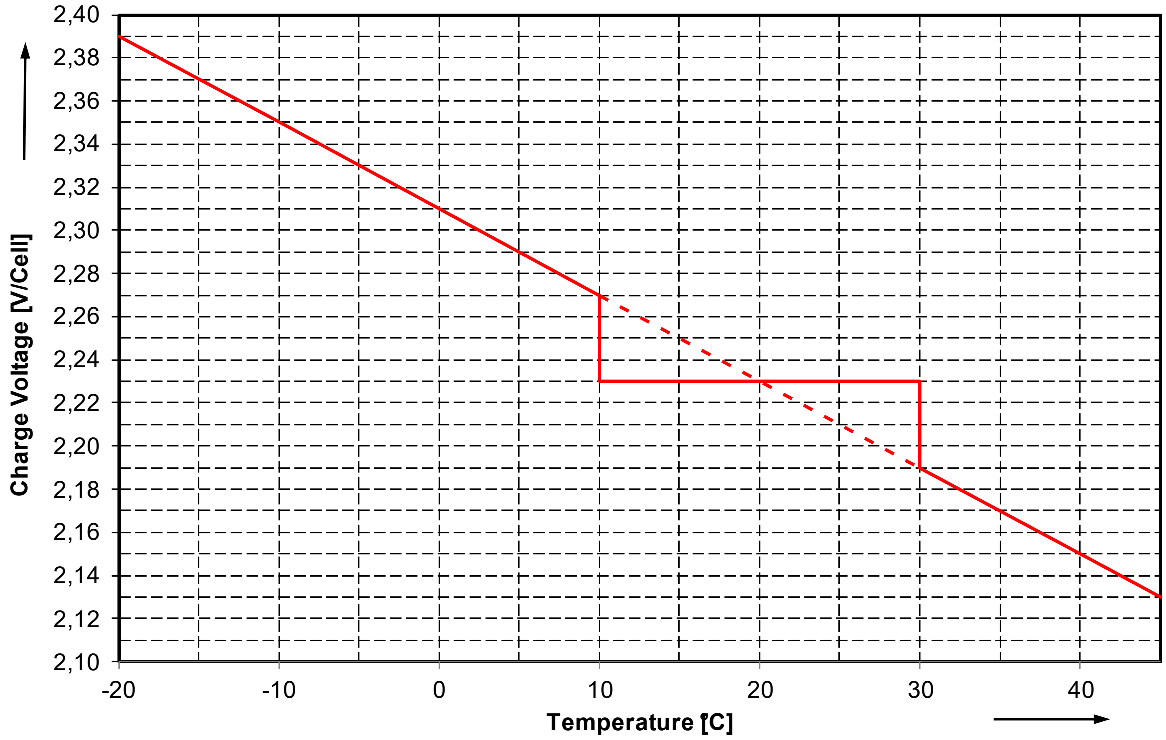



*Figure 7.2.2-1- Temperature-dependent adjustment of the charging voltage*

**Maximum charging currents**

Up to 2.4 V/cell the battery is able to absorb the maximum current the battery charger provides. Using the IU characteristic according to the DIN 41773 a charging current of 10 A to 20 A per 100 Ah rated capacity (C10) is recommended. If charge voltages of 2.4 V/cell are exceeded, this leads to higher water dissociation and electrode stress. The charge currents per 100 Ah nominal capacity shown in Table 6-1 must not be exceeded when charging with a charge voltage of over 2.4 V/cell.

*Table 7-1- Charging currents*

| Loading method | Series | Voltage |
|---|---|---|

| | grid \| power VL<br>grid \| power VM<br>grid \| power VH | grid \| power V X | |
|---|---|---|---|
| I-characteristic curve (DIN 41776) | 5.0 A | 6.5 A | 2.6 to 2.75 V/cell |
| W characteristic curve (DIN 41774) | 7.0 A<br>3.5 A | 9.0 A<br>4.5 A | at 2.4 V/cell<br>at 2.65 V/cell |

### 7.2.3 Float charging

Float charging serves to maintain the full charge state of the battery(s).

Use a charger with the specifications according to DIN 41773 (IU characteristic curve). Adjust the charging voltage so that the average cell voltage is the same as specified in Table 7-2.

*Table 7-2 - Charge float voltage in standby parallel operation*

| Battery | Float Voltage |
|---|---|
| grid \| power V X (GroE) | 2.23 ± 1 % V/Zelle |
| grid \| power V L (OPzS / OPzS bloc) | 2.23 ± 1 % V/cell |
| grid \| power V M (OSP. HB / OSP. HC) | 2.23 ± 1 % V/cell |
| grid \| power V H (Ogi bloc) | 2.23 ± 1 % V/cell |
| grid \| power V H (OSP. XC) | 2.25 ± 1 % V/cell |
| sun \| power V L | 2.23 ± 1 % V/cell |

### 7.2.4 Equalizing charge (correction charge)

Under normal circumstances, equalizing charges are not necessary. If there are unacceptably large discrepancies between the cell voltages of the individual cells at float charge (see 7-3), an equalizing charge must be performed.

Equalizing charges are also required after deep discharges, after insufficient charging processes, if the cells have been unevenly warm for a long time (≥ 5K) or if the electrolyte density (temperature-adjusted) in one or more cells deviates from the target value by more than 0.01 kg/l.

*7-3 - Permissible differences in cell voltage while maintaining charge*

| Voltage per unit | Max. permissible deviation of the float charge voltage from the mean value for single cells/blocks |
|---|---|
| 2 V | - 0.5 V / + 0.10 V |
| 4 V | - 0.07 V / + 0.14 V |
| 6 V | - 0.09 V / + 0.17 V |
| 12 V | - 0.12 V / + 0.25 V |

**Example for grid | power V L cells:** Float charge voltage max. = 2.33 V/cell and min. 2.18 V/cell (with average charge float voltage of 2.23 V/cell).

Attention!

As the max. permitted load voltage might be exceeded it must be clarified in advance whether the loads can be disconnected for the duration of the equalizing charge.

Perform the equalizing charge as follows:

1. Charging at a constant voltage of max. 2.4 V/cell for up to 72 hours. The charging current must not be higher than 20 A per 100 Ah nominal capacity.
2. Stop charging when the maximum temperature exceeds 55°C or continue with reduced current. You can also temporarily switch to “float charging” to allow the temperature to drop.
3. The end of the equalization charge is reached when the cell voltages no longer rise within 2 hours.

# 8 Battery maintenance

Regular care and maintenance of your battery system is essential for the required reliability and longevity. You should document the type and extent of the maintenance work as well as all measurement results as well as possible. The records can be very helpful for troubleshooting and are a prerequisite for any warranty claims.

Take the following measurements regularly and record the measured values:

| Interval | Activity | Reference |
|---|---|---|
| 6 months | Visual inspection of the entire battery system / cleaning of the battery | Chap. 8.1 |
| | Measuring the charging voltage of the entire battery system | Chap. 8.2 |
| | Measuring the individual voltage of some cells or block batteries | Chap. 8.2 |
| | Measuring the electrolyte density of some cells or block batteries | Chap. 8.3 |
| | Measuring the electrolyte temperature of some cells or block batteries | Chap. 8.3 |
| | Checking the electrolyte level of all cells or block batteries / Refilling distilled water | Chap. 8.4 |
| | Measuring the temperature in the battery compartment | Chap. 8.2 |
| 12 months | Measurement of the individual voltage of all cells or block batteries | Chap. 8.2 |

| | | |
|---|---|---|
| | Measurement of the electrolyte density of all cells or block batteries | Chap. 8.3 |
| | Measurement of the electrolyte temperature of all cells or block batteries | Chap. 8.3 |
| | Measuring the insulation resistance of the battery system | Chap. 8.5 |
| | Testing of all unsecured screw connections for tight fit | Chap. 8.6 |
| | Checking the proper ventilation of the battery compartment | Chap. 6.1.1 |
| 3 years | Capacity testing (recommended), shorten the testing interval with age | Chap. 8.7 |

If the float charge voltage at a cell deviates from the mean value by more than +0.1 V or -0.05 V, see chap. 7.2.4, carry out an equalizing charge as a control measure or request after-sales service.

The maintenance and care work described here must also be carried out when using grid | AquaGen recombination systems. This also includes checking and, if necessary, balancing the electrolyte levels in the battery cells.

HOPPECKE recommends using a stationary battery monitoring system to monitor relevant data. Please contact your local HOPPECKE representative.

## 8.1 Inspection for cleanliness and cleaning of the battery system

Danger!

Regular cleaning of the battery is necessary to ensure availability and compliance with accident prevention regulations. The battery should be cleaned at least once a year. The following should be observed:
When cleaning the battery, face protection (impact-resistant visor according to EN 166 Class F or comparable), safety goggles and protective clothing must be worn. To avoid electrostatic charge when handling batteries, textiles, safety shoes and gloves must have a surface resistance ≤ $10^8$ ohms.

Attention!

The cell plugs or grid | AquaGen recombination systems must not be removed or opened for cleaning.

Danger!

Do not use dry cleaning clothes when cleaning!
The grid | AquaGen recombination system should be cleaned with a slightly damp cotton or paper towel in the same way as the cell/block containers of the batteries. Note: The grid | AquaGen housings can become hot during battery charging, especially during heavy charging. Cleaning should therefore not be carried out during heavy battery charging.

Keep the battery clean and dry, as dust and moisture can lead to leakage currents. During the visual inspection, check the battery, the screw connections and the battery rack or battery cabinet for dirt or mechanical damage. The battery must be cleaned if it becomes dirty. The plastic parts of the battery, particularly the cell containers, may only be cleaned with water or water-soaked cleaning cloths without additives. After cleaning, the battery surface must be dried using suitable means, e.g. with water-moistened antistatic cleaning clothes (e.g. cotton).

Note: In grid | power V M and grid | power V H cells, streaks may form on the inside of the cell vessel. These deposits are primarily found in the area of the electrolyte surface. This is caused by additives that act as antioxidants in the separator material to protect the plastic material of the separator. It is unavoidable that small amounts of this additive are washed out over time and deposited. This phenomenon has no negative effect on the electrical performance data of the battery or on the service life.

## 8.2 Measuring the charging voltage

The measurement of voltage values is used to detect and identify faults. Recording the measured voltage values helps with this. Measure the charging voltage of the battery system or the individual cells or block batteries and check the measured values against the specifications applicable to the battery type in chap. 7.2.4. Also measure the room temperature.

## 8.3 Measuring electrolyte density and temperature

**Measuring electrolyte density: prerequisites**

The electrolyte density decreases during the discharging process of the battery and increases during the charging process. As it also depends on the temperature (see above) and the fill level in the battery, these two values should always be determined and noted when measuring the density. The best way to measure the characteristic values is via the service opening provided.

**Prerequisites for measuring electrolyte density using hydrometers:**

- No water has been added to the battery in the last few days (electrolyte stratification). Water has a lower density than sulfuric acid (i.e. it is lighter), so mixing takes time
- The battery has been charged for at least 72 hours
- The electrolyte level in the battery is correct
- The temperature is 20 °C. If this is not the case, it must be converted accordingly.

*Figure 8-1 - Hydrometer*

**Dependence of electrolyte density on temperature**

The electrolyte is diluted sulfuric acid. The nominal density of the electrolyte refers to 20 °C and the nominal electrolyte level in a fully charged state. The maximum permissible deviation is ± 0.01 kg/l.

Higher temperatures reduce the electrolyte density, lower temperatures increase the electrolyte density. The corresponding correction factor is 0.0007 kg/l per K.

Example: Electrolyte density 1.23 kg/l at 35 °C corresponds to a density of 1.24 kg/l at 20 °C or electrolyte density 1.25 kg/l at 5 °C corresponds to a density of 1.24 kg/l at 20 °C.

## 8.4 Refill distilled water

Each lead-acid battery decomposes a certain amount of water into hydrogen and oxygen. This effect increases with the number of charging and discharging processes, with increasing voltage, as well as with increasing battery temperature and battery age. Check the electrolyte level of each cell or block using the markings on the housing. If the level falls below the maximum mark and it is foreseeable that it will fall below the minimum mark in the next few weeks of operation until the next maintenance, fill distilled water via the cell or service opening (chap. 6.6.4.4).

## 8.5 Measuring insulation resistance

The insulation resistance of a battery is a measure of conductivity that results from moisture and contamination of the battery between the battery terminals and the housing (rack/cabinet). Ideally, there is no electrical conduction here if the insulation resistance of the battery is infinitely large.

When commissioning a new battery, the insulation resistance must be > 1 MΩ. This value falls with the operating time (caused by aerosols from the batteries, condensation and dust) and must not fall below the value of 100 Ω per volt of nominal voltage in accordance with IEC 62485-2.

**Minimum value for the battery system:**

100 Ω x 2 V x number of battery cells in series. In the case of block batteries, the nominal voltage of the block battery and the number of blocks is applied accordingly.

For grid | power batteries, an insulation measuring device with a test voltage of 500 V/1000 V can be used (according to DIN VDE 0100-600). Use a suitable measuring instrument, e.g. GOSSEN METRAWATT METRISO 5000 D-PI.

Nominal voltage of the battery ≤ 500 V = Set the meter to 500 V/DC, 1 minute

Nominal voltage of the battery > 500 V = Set the meter to 1000 V/DC, 1 minute

Danger!

An insulation test voltage of 500 V/1000 V can damage other components connected to the battery. Disconnect the battery from the load when measuring the insulation resistance.

Danger!

When measuring with an insulation resistance meter, there is a risk of electric shock. Observe and follow the safety precautions described in the documentation of the insulation resistance measuring device.

## 8.6 Checking the screw connections

A tight fit of the screw connections is important to avoid increased contact resistances and thus to avoid a loss of performance or increased heating. Therefore, use a torque wrench to check the screw connection for the values specified in chap. 6.6.7.

## 8.7 Check the battery system

### 8.7.1 Preparing the battery system for capacity testing

We recommend carrying out an equalizing charge on the battery system before the test. This equalization charge should be carried out no more than 7 days ago and at least 3 days!

The most efficient and fastest method for preparing batteries for tests is the IU charging method, which is also used for equalizing charges. Appropriate measures must be taken if the permissible load voltages are exceeded, e.g. switching off the loads. The IU characteristic curve with an increased voltage of (2.33 to 2.40 V) x number of cells is the most common charging characteristic curve for recharging or commissioning batteries.

Charging is carried out with a constant voltage of max. 2.33 V to 2.40 V/cell for up to 48 hours. The charging current should not exceed 20 A per 100 Ah $C_{10}$. If the battery temperature (cell/block temperature) exceeds the maximum value of 45 °C, charging must be interrupted or temporarily switched to float charging so that the temperature drops.

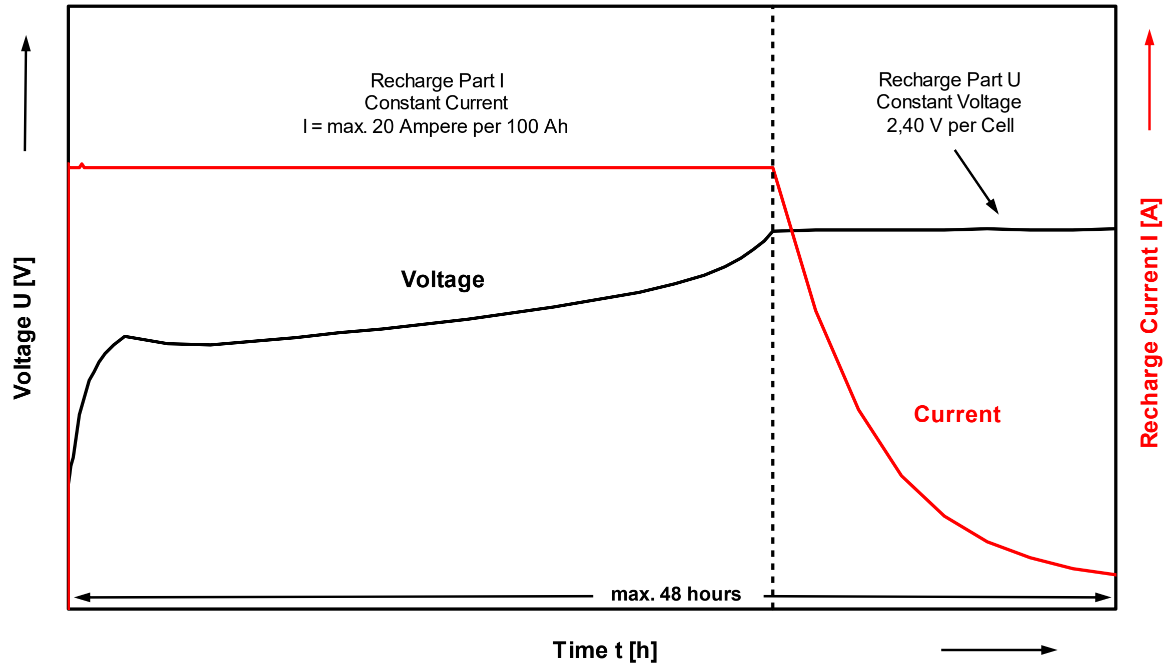



*Figure 8-2 - Characteristic curve IU*

Further characteristic curves are possible according to W or I characteristics. The charging voltages increase to (2.60 to 2.75 V) x number of cells. As a rule, the loads must therefore be switched off beforehand. With the W or I characteristic, the charging currents are not limited until the charging voltage has reached the gassing voltage of 2.40 V x number of cells.

According to this, the following limit values apply: Limit values of the charging currents above the gassing voltage of 2.40 V/cell per 100 Ah.

*Table 4 - Charging current and cell voltage as a function of the charging method*

| Loading method | Charging current | Cell voltage |
|---|---|---|
| I-characteristic curve | 5.0 A/100 Ah | 2.60 – 2.75 V/cell |
| W characteristic curve | 7.0 A/100Ah<br>3.5 A/100Ah | at 2.40 V/cell<br>at 2.65 V/cell |

An even more effective method of preparing the batteries is the IUIa charging method, which involves an additional constant current charging step. In contrast to charging with constant voltage, a constant charging current of 5 A/100 Ah is switched on for 3 hours in the last step after the IU charging has been completed. The charging voltage can rise to up to 2.6 V to 2.75 V per cell.

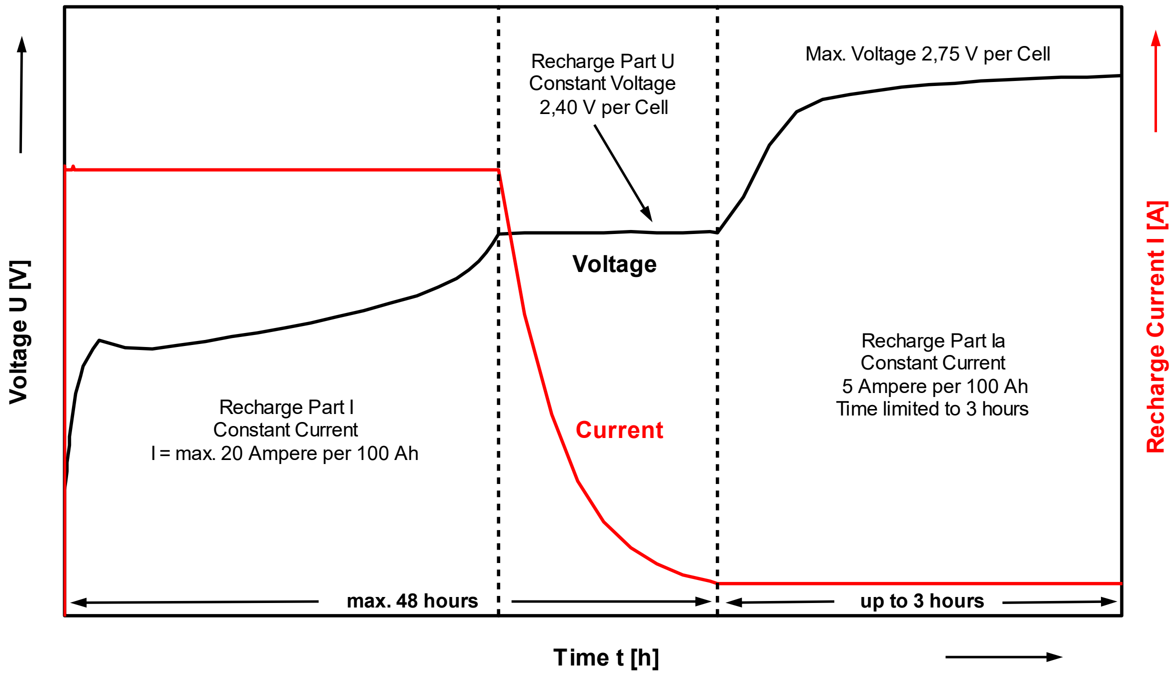



*Figure 8-3 - Characteristic curve IUIa*

Due to the increased gas development in the W, I or IUIa charging method, increased ventilation of the battery compartment is necessary. A full charge of the battery is generally achieved if the charging voltage/charging current (depending on the charging method) and the electrolyte density no longer change within 2 hours.

## 8.7.2 General information on how to carry out the capacity check

Tests shall be carried out in accordance with EN 60896-11: "Stationary lead-acid batteries", Part 11: "Vented types – General requirements and methods of tests" (IEC 60896-11:2002). Special test instructions, e.g. according to DIN VDE 0100-710 and DIN VDE 0100-718, must also be observed.

**Necessary accessories:**

- Suitable electronic load or electrical resistance (with adjustable resistance value to adjust the discharge current/discharge load)
- Suitable current clamp with sufficient accuracy to measure the DC current or shunt to measure the discharge current
- Voltage meter for measuring electrical voltage
- Thermometer to check the battery temperature
- Clock for measuring discharge time
- Acid density meter for vented batteries with a measuring range of 1.10kg/l to 1.29kg/l
- Project planning data table for selecting the correct discharge current or discharge power

Requirements for the accuracy class of the above-mentioned measuring equipment can be found in Table 8-5.

*Table 8-5 - Requirements for the accuracy of the measuring instruments (accuracy class)*

| | |
|---|---|
| For voltage measurement: | 0,5 |
| For current measurement: | 0,5 |
| For temperature measurement: | 1 °C |
| For timekeeping: | 1 % |
| Acid density: | 0.005 kg/l |

Below you will find general information on how to determine the actual capacity of your battery system.

1. Make sure all connections are clean, tight, and not corroded.
2. During normal battery operation, measure and record the following parameters:
    - Individual voltage of all cells or block batteries
    - Electrolyte density
    - Surface temperature of at least one in ten cells or block batteries
    - Voltage of the total battery system
3. Interrupt the connection of the battery system to be measured to the charger and to all consumers!
4. Prepare an adjustable load that you can connect to the battery system. The load current must be equal to the maximum allowable current for which the battery is designed.
5. Provide a shunt that you can connect in series with the load.
6. Provide a voltmeter so that you can measure the total voltage of the battery.
7. Connect the load, the shunt and the voltmeter and start a time measurement at the same time.
8. Keep the current constant and measure the voltage of the battery system at regular intervals.
9. Check the row connectors (block connectors), step connectors and tier connectors for impermissibly high heating.
10. Calculate the capacity of the battery system using the following equation:
    Capacitance [% at 20 °C] = $(T_a/T_s) \times 100$
    Ta = actual discharge time until the allowable minimum voltage is reached
    Ts = theoretical discharge time until the permissible minimum voltage is reached
11. Reconnect the battery system as originally and perform a boost charge.

### 8.7.3 Implementation of the capacity test and evaluation

The battery is discharged in accordance with the regulations for carrying capacity tests DIN EN 60896-11. The discharge current and the discharge power are selected according to the project planning data tables up to a certain final discharge voltage and the given loads.

In the capacity test, after 10% of the discharge time has elapsed, the discharge current or discharge power, temperature, battery voltage as well as the cell or block voltage and the discharge time should be recorded.

In any case, however, the values at 10%, 50%, 80% and 95% of the discharge time must be recorded. The discharge shall be terminated when the battery voltage has reached the value n x $U_f$, where n is the number of cells and $U_f$ is the selected final discharge voltage per cell.

The discharge must also be stopped as soon as a cell has reached a voltage of $U = U_f –$ 200 mV or, in the case of block batteries with n cells each, as soon as the voltage of a block $U = U_f – \sqrt{n} \times 200$ mV has reached.

**Example:**

13 Cells grid | power V X 2-300 5h capacity test Battery final voltage = 23.40 V (for 13 cells) Average voltage per cell = 1.80 V Minimum single cell final voltage = 1.60 V

*Table 8-6 - Measured cell voltages and total voltage after 95% of the required discharge time*

| Cell number | Case A | Case B | Case C |
|---|---|---|---|
| 1 | 1,84 | 1,84 | 1,79 |
| 2 | 1,83 | 1,86 | 1,80 |
| 3 | 1,83 | 1,87 | 1,81 |
| 4 | 1,84 | 1,87 | 1,80 |
| 5 | 1,84 | 1,86 | 1,81 |
| 6 | 1,85 | 1,86 | 1,79 |
| 7 | 1,69 | 1,87 | 1,78 |
| 8 | 1,84 | 1,86 | 1,80 |
| 9 | 1,83 | 1,59 | 1,81 |
| 10 | 1,85 | 1,84 | 1,81 |
| 11 | 1,84 | 1,85 | 1,80 |
| 12 | 1,84 | 1,85 | 1,79 |
| 13 | 1,85 | 1,85 | 1,79 |
| **Battery** | 23,77 V | 23,87 V | 23,38 V |

Case A: A "weak cell", capacity test passed, battery OK

Case B: One cell faulty, capacity test not passed, battery not OK.

Case C: All cells OK, capacity test failed, battery not OK

Immediately after the capacity test, the battery must be charged. The measured capacity C (Ah) at the average initial temperature is calculated as the product of the discharge current (in amperes) and the discharge time (in hours). Since the battery capacity depends on the temperature, a temperature correction of the measured battery capacity must be performed.

At temperatures above the nominal temperature of 20 °C, the battery capacity increases, while at lower temperatures it decreases. If the average initial temperature deviates from the reference temperature of 20 °C, the capacity must be adjusted. The temperature correction is carried out in accordance with the DIN EN 60896-11 standard according to equation [1].

$$C_a = \frac{C}{1 + \lambda\,(\vartheta - 20°C)} \qquad [1]$$

C = measured capacity
$\lambda$ = Correctionfactor ($\lambda$= 0.006 for discharges > 3 h and $\lambda$ = 0.01 for discharges ≤ 3 h)
$\vartheta$ = Initial Temperature
$C_a$ = corrected capacity

According to the DIN EN 60896-11 standard, a capacity test is considered to have been passed if the battery reaches 95% of the required capacity at the first discharge. The battery must deliver 100% of the required capacity after the fifth discharge at the latest.

A report must be drawn up after discharging (see test report).

When handling batteries (e.g. capacity test), the safety requirements according to IEC 62485-2 (insulated tools, eye protection, protective clothing, gloves, ventilation, etc.) must be observed!

Attention!

## 8.8 Notes on impedance measurement

Impedance measurement can also be used to check batteries. Please note that there is no standardized measurement rule for this method and there are a few things to consider when using it.

To use the results of an impedance measurement sensibly and correctly, follow the instructions in the ZVEI Leaflet No. 34.

# 9 Troubleshooting

If faults are detected on the battery or the charging system, customer service must be called immediately. Measurement data in accordance with chap. 8 simplifies troubleshooting and fault rectification. A service contract with us makes it easier to detect faults in good time.

## 9.1 Scattering of the individual cell voltages

If you notice that the individual cell voltages differ (see chap. 7), proceed as follows:

| **Possible cause** | **Remedy** |
|---|---|
| Different cell temperatures | Check the charger |
| Different electrolyte densities of the cells (VLA batteries) | Carry out an equalizing charge, see chap. 7 |
| Plate shorts in one or more cells | Measuring cell voltages, replacing defective cells |
| Different charge levels of the cells/block batteries | Carry out an equalizing charge, see chap. 7 |
| Insulation resistance too low | see chap. 9.3 |
| Lead-acid battery with fixed electrolyte (gel) | Normal behaviour within the first years of operation, see chap. 7 |

## 9.2 Available capacity too low

Insufficient capacity can be due to the following causes:

| **Possible cause** | **Remedy** |
|---|---|
| Electrolyte Stratification (VLA) | Carry out an equalizing charge, see chap. 7 |
| Electrolyte levels below the minimum (VLA batteries) | Refill distilled water, see chap. 8 |
| Loose or oxidized terminal terminals | Check all connections, replace connectors if necessary. |
| Insulation resistance too low | see chap. 9.3 |

## 9.3 Insulation resistance too low

According to DIN EN IEC 62485-2, the minimum insulation resistance between the battery circuit and other local conductive parts must be greater than 100 Ω per volt (the nominal voltage of the battery). In the event of an insulation fault, leakage currents can reduce the available capacity of the battery. This entails the risk of different cell voltages occurring. Regular cleaning can prevent these leakage currents and different cell voltages.

| Possible cause | Remedy |
|---|---|
| Battery contamination | Cleaning the battery, see chap. 8.1 |
| Leaks in a cell/block | Fix the cause of the leak; if necessary, replace the cell, see chap. 9.5 |

## 9.4 Battery voltage not measurable

If no battery voltage is measurable, do the following:

| Possible cause | Remedy |
|---|---|
| A fuse has tripped | Search for the fault, switch or replace the fuse |
| Cable break | Replace cables |
| Defective connectors | Replace connectors |

## 9.5 Replacement of a cell/battery in the string

It is essential to make sure that the exchange is de-energized. Before disconnecting the connectors, the circuit must be switched off.

Attention!

After loosening the connectors, cells/block batteries must be moved, please refer to the instructions in the chap. 6.6. Lifting the cells/block batteries at the terminals is prohibited, as this will destroy the cells/block batteries.

**Removal of the defective cell / block battery:**

1. disconnect the supply lines (circuit breakers, fuses, switches) before starting disassembly. Only to be carried out by authorized personnel! Check that the battery is disconnected from all charging equipment and consumers.
2. Loosen the terminal screws and connectors of the affected battery and remove them directly from the battery.
3. Lighter cells/block batteries can be lifted directly out of the rack manually if space permits.
4. In the case of heavy cells/block batteries, it is necessary to dismantle other elements of the affected rack row to facilitate access. The position of the defective cell/block battery and local conditions will determine which additional elements need to be removed.
5. Use soft soap to make it easier to move the batteries sideways over the support rails of the rack. When moving the batteries sideways in the rack, do not press in the middle, but around the (stiffer) corners. Only press by hand, never use tools!

6. Slide the batteries onto the mobile assembly platform positioned to the side of the rack and store temporarily for reassembly.
7. Remove the defective cell/block battery from the rack in the same way.

The integration of the cell into the cell network may only take place after successful commissioning.

**Installation of filled and charged batteries**

If a cell or a block in a battery string needs to be replaced and the replacement cell/block is **filled and charged**, the procedure is described in chap. 6.6.

**Installation of unfilled and charged batteries**

If a cell or a block in a battery string needs to be replaced and the replacement cell/block is **unfilled and charged**, the generally recommended procedure from chap. 6.6 is followed.

The integration of the cell into the cell network may only take place after successful commissioning.

## 9.6 Distilled water consumption

During the charging process, electrolysis decomposes the water of the electrolyte into the gases $2H_2 + O_2$. This leads to a reduction in electrolyte levels. The volume of the decomposed water depends on the charging voltage, the charging time per day and the temperature. If you notice excessive consumption of distilled water, do the following:

| Possible cause | Remedy |
|---|---|
| Charging voltage too high | Check the charger |
| Scattering of the individual cell voltages | See chap. 7.2.4 |
| Contaminated electrolyte | Check the electrolyte for contamination, contact Hoppecke if necessary. |

# 10 Disassembly

When dismantling a battery system, all safety instructions listed in this document must be considered, see chap. 2. This includes, in particular, personal protective equipment, safety clothing and the use of insulated tools.

Follow these steps:

- Disconnect the supply lines (circuit breakers, fuses, switches) before starting disassembly. To be carried out by authorized personnel. Check that the battery is disconnected from all charging equipment and consumers.
- If the electrolyte level is not at the max mark due to inadequate maintenance, the electrolyte level must be set to the max mark before any further disassembly work is carried out.
- If the battery system is equipped with HOPPECKE grid | AquaGen recombination systems or ceramic funnel plugs, these must be removed in accordance with the relevant operating instructions and the cells/blocks filled with demineralized water up to the max. mark. The openings of the battery cells/blocks must then be sealed with the original bayonet plugs with inserted labyrinth inserts.
- For battery systems with a nominal voltage > 60 V, first remove the group and level connectors in order to divide the battery system into smaller partial voltages.
- Then remove the connectors between the cells/blocks.
- Loosened connectors and terminal screws must be removed from the battery immediately.
- Ensure that the battery cells/blocks are aligned vertically at all times during removal, packaging and transportation. Avoid tilting the battery cells/blocks to prevent acid leakage.
- The cells/blocks must be packed for transportation in accordance with ADR 598B. Externally damaged cells must be packed and transported separately (e.g. in a palox). See also chap. 4.

# 11 Parameter data sheet for sun | power V L batteries

This chapter contains instructions for charging the HOPPECKE sun | power V L battery cells and blocks in solar applications.

| **Parameter** | **sun \| power V L without Electrolyte Circulation Pump** | **sun \| power V L without Electrolyte Circulation Pump** |
|---|---|---|
| **Standard charging (regular cycle operation)** | | |
| Characteristic curve | IU (followed by switching to float) | IU (followed by switching to float) |
| Max. Current (observe fuses and cable lengths)<br>**Note:** Cable resistance must be configurable! | 6 x $I_{10}$ | 6 x $I_{10}$ |
| Max. voltage in absorption phase | 2.55 Vpc | 2.4 Vpc |
| Recommended absorption time | 180 min | 180 min |
| Absorption Time<br>Full Charge /Charge Factor | 6 h/charge factor 1.2<br>The absorption phase (or the recharging phase) can last longer or shorter than the 6 h, depending on the charging factor.<br>Compliance with the charge factor is primary (recommended). | 6 h/charge factor 1.05<br>The absorption phase (or the recharging phase) can last longer or shorter than the 6 h, depending on the charging factor.<br>Compliance with the charge factor is primary (recommended). |
| Frequency/cycle based on time period/full charge | 14 days | 14 days |
| **Float charge** | No switching due to threshold value for charging current! | No switching due to threshold value for charging current! |
| Voltage | 2.23 Vpc ± 1% | 2.23 Vpc ± 1% |
| Temperatur compensation | 4 mV/K | 4 mV/K |
| **Equalizing charge (frequency depending on which of the following criteria occurs first)** | | |
| Frequency/cycle based on capacity throughput | 10 x Cn | 10 x Cn |
| Frequency/cycle based on time period | 40 days | 40 days |
| Characteristic curve | IU/IUIa (followed by switching to Float) | IU/IUIa (followed by switching to Float) |
| Note on the characteristic curve | For IUIa characteristic curve: current in Ia phase | For IUIa characteristic curve: current in Ia phase |

| | | |
|---|---|---|
| | max. 5 A/100 Ah $C_{10}$ for 2 to 4 h | max. 5 A/100 Ah $C_{10}$ for 2 to 4 h |
| Max. Current (observe fuses and cable lengths) | 6 x $I_{10}$ | 6 x $I_{10}$ |
| Max. voltage absorption phase | 2.55 Vpc at IU-characteristic curve<br>2.4 Vpc at IUIa-characteristic curve | 2.55 Vpc at IU-characteristic curve<br>2.4 Vpc at IUIa-characteristic curve |
| Absorption Time/Charge Factor | 8 h/charge factor 1.3<br>The absorption phase (or the recharging phase) can last longer or shorter than the 8 h, depending on the charging factor.<br>Compliance with the charge factor is primary (recommended). | 8 h/charge factor 1.3<br>The absorption phase (or the recharging phase) can last longer or shorter than the 8 h, depending on the charging factor.<br>Compliance with the charge factor is primary (recommended). |
| **Battery Discharge** | | |
| Discharge characteristics | See data sheet and project planning data | See data sheet and project planning data |
| Recommended (DOD) Cycle Operation | 50 % | 50 % |
| Max. depth of discharge (DOD), immediate recharging required | 80 % | 80 % |
| Max. Discharge current<br>Note: Line resistance must be configurable! | Limited by BattFuse and cabling | Limited by BattFuse and cabling |
| Proposal for characteristic curve for deep discharge protection [U=f(I)]<br>Note: Deep discharge protection by switching off at only constant voltage value is not permitted! | 1.98 Vpc at $I \leq 0.16 \times I_{10}$<br>1.81 Vpc at $I \geq 4 \times I_{10}$ linear interpolation with<br>$0.16 \times I_{10} < I < 4 \times I_{10}$ | 1.98 Vpc at $I \leq 0.16 \times I_{10}$<br>1.81 Vpc at $I \geq 4 \times I_{10}$ linear interpolation with<br>$0.16 \times I_{10} < I < 4 \times I_{10}$ |

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